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ACUTE INFECTIOUS CROUP

A GENERAL STUDY OF ACUTE OBSTRUCTIVE INFECTIONS OF THE LARYNX, TRACHEA, AND BRONCHI WITH AN ANALYSIS OF 727 CASES

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PART I. DIPHTHERITIC CROUP

INTRODUCTION

THE name "croup" is generally applied to any affection of the larynx and trachea producing difficult and noisy respiration and a hoarse cough. Originally derived from the Anglo-Saxon word "kropan" meaning "to cry aloud," it is characterized by the very opposite, namely, an inability to cry aloud or to phonate at all in many cases. Some writers use the word "croup" by itself to imply a diphtheritic croup, others a so-called catarrhal croup; others employ the terms "true croup," "false croup," and "spasmodic croup," while still others use the word in conjunction with the underlying pathology, such as catarrhal, membranous, pseudomembranous, and fibrinous croup. This mixed terminology is obviously confusing. Moreover, the confusion is increased by the fact that the use of pathologic qualifications alone is inadequate, because totally different agents can elicit identical tissue reactions and similar symptoms; and the same agents, different tissue reactions and different symptoms.

For these reasons, and in order to provide a comprehensive working conception, the word "croup" is here broadly defined as the *symptom-*

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complex due to any stenosis of the laryngotracheal air passages, and the condition is classified below upon an etiologic basis.

CLASSIFICATION OF CROUP

I. Congenital malformations
   A. Exaggerated infantile type of larynx[1, 2]
   B. Laryngeal papilloma*
   C. Web
   D. Small lumen
   E. Absent tracheal rings
   F. Macroglossia with micrognathia[3, 4]

II. Neuromuscular
   A. Spasmodic
      1. Transient spasms of indefinite etiology
      2. Laryngismus stridulus—tetany*
      3. Tetanus
      4. Epilepsy
      5. Chorea
      6. Hysteria
      7. Laryngeal crises in locomotor ataxia
      8. Hydrophobia
      9. Physical allergy[5]
      10. Pressure on vagus nerve (such as by newgrowths in mediastinum)
      11. Local irritation (foreign body, infections, tumors, medicaments)
   B. Paralytic
      1. Locomotor ataxia
      2. Multiple sclerosis
      3. Cerebral syphilis
      4. Influenza
      5. Ptomaine poisoning
      6. Plumbism
      7. Bulbar poliomyelitis*
      8. Diphtheria
      9. Pressure on vagus nerve (mediastinal or esophageal neoplasm)
      10. Myasthenia gravis[6]

III. Tumors of wall of larynx or trachea*

IV. Occlusion from without
   A. Foreign body in esophagus*
   B. Abscess (paralaryngeal, paratracheal, mediastinal)*
   C. Ludwig's angina
   D. Enlarged thymus
   E. Enlarged thyroid
   F. Enlarged lymph glands
      1. Due to infections
      2. Neoplastic
      3. In blood dyscrasias*
      4. In Hodgkin's disease
   G. Newgrowths, benign or malignant
   H. Aneurysm
   I. Diverticula of pharynx or esophagus
   J. Enlarged pendulous tonsils

V. Plugging of lumen by extraneous matter
- A. Foreign body in larynx or trachea*
- B. Mucous plug in larynx or trachea*
- C. Mucus from above (in bulbar poliomyelitis)
- D. Blood from above or below*
- E. Pus from above or below*

VI. Traumatic
- A. Digital or instrumental
- B. Chemical (inhalation)
- C. Steam or hot fluids
- D. Fracture of larynx

VII. Edema of larynx secondary to systemic disease
- A. Anaphylaxis
- B. Cardiac failure
- C. Nephritis
- D. Angioneurotic edema
- E. Potassium iodide poisoning

VIII. Infectious
- A. Chronic
  1. Syphilis
  2. Tuberculosis
  3. Leprosy
  4. Rhinoscleroma
  5. Granuloma inguinale
  6. Pemphigus
  7. Perichondritis
- B. Acute
  1. Specific
     a. *Diphtheria**
     b. Fungus*
     c. Vincent's infection*
     d. Typhoid
     e. Varicella*
     f. Variola
     g. Herpes
     h. Erysipelas
  2. Nonspecific
     a. Laryngeal abscess*
     b. Chondritis
     c. *Acute nonspecific infectious croup**
     d. Acute nonspecific croup associated with specific infectious diseases*
        (1) Measles*
        (2) Scarlet Fever*
        (3) Pertussis*
        (4) Influenza*
        (5) Acute rheumatic fever
     e. Acute nonspecific croup associated with blood dyscrasias
        (1) Agranulocytosis*
        (2) Leucemias

*Cases marked with asterisk are described in this paper.

The paucity of detailed and unified information in the literature concerning the various methods of treatment and their indications and the constant requests for this information received by the Willard Parker Hospital from physicians in many parts of the world have prompted us to present this paper.

The present study is an analysis of 727 consecutive cases of patients suffering from croup who were treated by or under the supervision of the authors with the help of the attending staff at the Willard Parker Hospital between June 1, 1931, and June 1, 1934. This work, done in a hospital for communicable diseases, naturally does not include many of the groups listed above, such as those due to the chronic infections of adult life, nor the transient laryngeal spasms of infancy and early childhood. It concerns itself chiefly with two types of acute infectious croup, namely, those of diphtheritic and nonspecific origin. Under the latter grouping, cases with measles, scarlet fever, pertussis, and varicella are discussed. Some other interesting cases of croup are decribed more briefly.

Diphtheritic Croup

CLASSIFICATION

The infection is usually secondary to that in the nose and throat but may sometimes be primary in the larynx, trachea, and bronchi. Some of the secondary type occur in association with severe toxic faucial diphtheria. Regardless of point of origin and degree of toxicity, the cases of diphtheritic croup readily lend themselves to subgrouping *according to the extent* of membrane formation, so far as this could be determined.

Group I. Simple laryngeal

Group II. Laryngotracheal

Group III. Laryngotracheobronchial and tracheobronchial

No case was placed in Group III unless bronchial membrane was demonstrated. Since the bronchoscope was never used, it is likely that several of the cases placed in Group II did have some bronchial involvement.

INCIDENCE

Frequency.—Of the 727 cases of croup studied, 261, or 36 per cent, were due to diphtheria. These constituted 26 per cent of 1,009 diphtheria patients treated at the Willard Parker Hospital during the three-year period. The larynx was involved in 117 patients; the larynx and trachea, in 110; and the larynx, trachea, and bronchi, in thirty-four patients. In eight patients the infection was primary in the larynx. Twenty-five of the 261 croup cases had toxic faucial diphtheria.

Seasonal.—The disease was endemic the year round with the highest frequency in February and a low ebb in August, September, and October. The subgroups followed the general pattern of the entire group.

Age.—Under one year	14 cases
Between one and two years	59 cases
Between two and three years	46 cases
Between three and four years	52 cases
Between four and five years	30 cases
Between five and six years	13 cases
Between six and seven years	22 cases
Between seven and eight years	11 cases
Between eight and nine years	6 cases
Over nine years	8 cases

The age ranged from five months to fifty-three years. The percentage distribution was as follows:

Under one year	5 per cent
Under five years	77 per cent
Between five and nine years	20 per cent
Over nine years	3 per cent

The greatest frequency occurred between one and two years of age. There were fifty-nine cases, or 22 per cent of the whole series, in that age group. The age incidence of the subgroups paralleled the main group, except that in the first two years of life a higher proportion of patients fell into the laryngotracheobronchial group.

Sex.—Cases were fairly equally divided between the sexes. There were 146 males and 115 females, 56 per cent and 44 per cent. This general relationship obtained in the three subgroups.

LIVING PATHOLOGY

Due to the anatomic peculiarities of the structures involved, the significant pathologic changes are those leading to mechanical obstruction. These are three: edema, membrane formation, and mucopurulent exudation. Although their severity tends to be proportionate to that of the systemic invasion, they may be severe enough to cause death by mechanical occlusion even though the infection has been relatively innocuous to the organism as a whole.

Edema.—In the earliest stage, there is moderate congestion and superficial edema of the entire laryngeal mucosa. As the disease progresses, this grows more severe, especially in the subglottic region where loose areolar tissue fills the submucosa. If the tissues are not traumatized, the swelling usually subsides with the infection.

Membrane Formation.—At first the laryngeal mucosa is covered with a thin, adherent, whitish membrane, which is rather difficult to remove. If it is removed, it is found to be soft and friable and often indistinguishable grossly from exudate due to streptococcic or staphylococcic infection. However, microscopic examination may reveal the presence of Klebs-Löffler bacilli and establish the diagnosis. As the disease progresses, the membrane becomes thicker, firmer and easier to remove so that by the third or fourth day it is partly loosened and can be separated with almost no bleeding. At this stage, the gross character of the membrane is practically pathognomonic of diphtheria. Furthermore, the membrane varies as to form, location, and extent. In some cases it is patchy and limited to any one or more of the following: epiglottis, arytenoids, aryepiglottic folds, the false or true cords or to the subglottic region. In other cases, it completely covers all the laryngeal structures and may extend into the trachea, bronchi, bronchioles, and even line the alveoli. At times it was possible to remove intact, entire casts of the trachea and the bronchial ramifications.

Exudation.—In diphtheria, nonmembranous exudation, such as that present in other infections of the air passages, is, as a rule, relatively unimportant. However, it may occasionally become so abundant as to be a major factor in the obstruction.

The three contributing factors, edema, membrane formation, and exudation, are present in varying degrees in each patient. The predominance of one or more of these modifies the clinical picture, the treatment, and the prognosis.

Spasm of the vocal cords may, at times, contribute slightly toward exacerbation of the obstruction.

DIAGNOSIS

Onset.—The onset is, as a rule, not sudden. The patient may complain of anorexia, angina, and malaise and may have rhinitis and fever. Definite laryngeal involvement, as manifested by hoarseness and dyspnea, does not occur usually at the onset, but cough is present in about a third of the cases on the first day of illness. Thus, though the invasion of the larynx occurs very early, the involvement at that time is too slight to cause more than an irritative cough. The complaints on the initial day of illness, in the order of their frequency, are as follows:

Cough	35 per cent
Angina	33 per cent
Rhinitis	32 per cent
Fever	26 per cent
Hoarseness	16 per cent
Malaise	13 per cent
Dyspnea	10 per cent

Symptomatology.—The signs and symptoms of infectious croup are due to two factors, the systemic and local reactions to the infection. The local reaction, causing mechanical obstruction of the air passages, in its turn affects the physiology of the organism as a whole, so as to add a third group of symptoms. The combined syndrome is given in outline.

1. General
   - Fever
   - Acceleration of pulse
   - Anorexia
   - Malaise
   - Vomiting
   - Leucocytosis
2. Local
   - Cough
   - Hoarseness, aphonia
   - Dyspnea (stridor, retractions, suppressed breath sounds)
   - Roentgen-ray findings
3. General reaction to local obstruction
   - Acidosis, acetone bodies in the urine
   - Dehydration
   - Hyperpyrexia
   - Marked tachycardia
   - Marked tachypnea
   - Pallor, cyanosis
   - Anxious facies
   - Restlessness
   - Exhaustion, stupor, coma
   - Convulsions

Fever: The average admission temperature was 101.1° F. Thirty-six patients, or 14 per cent, had a temperature of 103° F. or more on admission. The age did not seem to have any particular effect upon the fever, but the extent of the involvement did have a striking influence. The admission temperature in half of the laryngotracheobronchial cases was 103° F. or more in sharp contrast with the other two groups in which the temperature rose to 103° F. in only one-tenth of the cases. The average temperature was 101° F. in the simple laryngeal group; 100.7° F., in the laryngotracheal group; and 102.5° F., in the laryngotracheobronchial cases. In mild infections, the temperature returned to normal in about three days.

Pulse: As in faucial diphtheria, the pulse rate was elevated out of proportion to the temperature. It was seldom below 130, except in the mildest cases with normal temperature.

Leucocytosis: The average number of white blood cells was 16,200 with a differential count of 73 per cent polymorphonuclear cells. No

relationship could be found to the age, the day of illness on which the count was made, the temperature elevation, or between the total white blood count and the proportion of polymorphonuclear leucocytes.

Hoarseness: Since membrane formation in the larynx usually includes the vocal cords, hoarseness is an early and constant symptom. Even in cases of only moderate severity, the voice is commonly completely lost. The cough, though "barking" at the onset, soon becomes short and constricted, often low pitched, and later toneless.

Dyspnea: As the membrane thickens and spreads, cough and hoarseness are followed by definite respiratory difficulty, which usually grows progressively worse. Remissions can occur if the child coughs up the obstructing membrane. That this membrane is often not discovered is probably due to its being swallowed. The breathing is stertorous with prolonged inspiration and expiration.

As the stenosis grows more complete, the effort to expand the chest wall tends to increase. The lung, however, is unable to expand with it, and the negative pressure in the pleural cavity is therefore increased. This causes an indrawing of the mobile portions of the thoracic cage with each inspiration. These retractions are first and most readily noticed in the soft tissues above the sternum and clavicles, later in the xiphoid region and intercostal spaces, and in very young children the entire sternum may be drawn in so that it seems to go as far back as the vertebral column. The younger the child the more mobile is the chest wall and proportionately deeper the retractions. Likewise, in rachitic children, retractions are greater in relation to the obstruction. The intercostal recession must be differentiated from the increased rib excursion and diaphragmatic contraction present in the labored breathing of nonobstructive origin. In very severe cases a downward movement of the larynx may be felt with each inspiration.

The expiratory phase of obstructive respiration is characterized by ballooning of the skin of the neck and by strong, expulsive contractions of the upper anterior abdominal muscles, causing spasmodic "bellying-up" of the lower midabdomen. The apices of the lungs are compressed during inspiration and filled during expiration in opposite phase to the rest of the chest. Such paradoxical breathing, with its interchange of gases from one part of the lung to another, lowers the oxygen concentration of the alveolar air and helps establish a vicious cycle of anoxemia development.[7]

In mild cases, auscultation of the chest reveals increased laryngeal stridor, often overshadowing the vesicular murmur, which can be heard best toward the end of inspiration. In more severe cases, the vesicular murmur disappears entirely, and in extreme stenosis even the stertor may be inaudible. If crepitant râles are heard, it is a sign that the obstruction is not extreme since a fair amount of air is neces-

sary to expand the moist alveoli and produce this type of râle. This may aid in evaluating the obstructive and nonobstructive components of dyspnea in cases complicated by pneumonia. Often the bronchi become involved unequally, causing a difference in the intensity of breath-sound transmission between the two lungs. This is seldom found in acute nonspecific infectious croup.

Systemic Reactions to Local Obstruction: In patients who suffer from extreme, prolonged obstruction, the following symptom-complex appears: The respirations grow more rapid and shallow, and the retractions become less marked despite the severe stenosis. The pulse becomes very rapid and thready, and the temperature climbs steeply, often reaching 106° F. in a few hours. The usual evidences of dehydration are present, and acetone bodies appear in the urine. The lips and nail beds may become cyanotic, but ashy pallor about the lips and nose is even more characteristic. The child has an anxious look and becomes very restless. If unrelieved, exhaustion supervenes and the child may become stuporous and comatose. Rarely, generalized convulsions occur.

Toxemia: This classical symptom of diphtheria has noticeably escaped mention thus far. Toxemia, as a direct result of the absorption of diphtheria toxins, has never been seen by us in a case of diphtheritic croup unassociated with severe throat involvement. It is generally recognized that the degree of toxemia produced by a diphtheritic infection varies with its location. The general order of diminishing toxicity is (a) pharyngeal, tonsillar, palatal, (b) nasal, and (c) laryngeal and tracheal.

Primary Tracheobronchial Diphtheria: In rare instances, the trachea and bronchi become infected without laryngeal involvement. Repeated references to such cases have been made in the literature. Lynah[8] in 1916 described thirty-eight cases supposedly of this type. However, careful analysis of his case studies reveals that all but seven, and these questionable ones, were not primary tracheobronchial infections. There are several possible causes for making such an incorrect diagnosis. First, the original site of invasion in the nose or tonsils may clear up by the time symptoms of obstruction to respiration develop. Second, the vocal cords may escape involvement while the rest of the larynx is infected, so that no hoarseness develops. Third, there may be a failure to make a direct laryngeal inspection. Fourth, the infection of the larynx may cause only congestion and swelling but no membrane formation. Finally, an intubation may have been performed, pushing membrane from the larynx into the trachea before an inspection of the larynx has been made. In the authors' experience there has been only one case of primary tracheobronchial diphtheria, and that a questionable one. As described by others,[9, 10, 11] the hoarseness is slight or

absent despite the severe dyspnea; the temperature is high; and the child has a toxemic, pneumonic appearance. Moreover, O'Dwyer[12] stated that in these cases the larynx is not drawn downward with inspiration.

DIAGNOSTIC LARYNGOSCOPY

On admission a direct, diagnostic laryngoscopy is performed in every case of croup in which there is the least doubt as to the nature of the infection. The larynx is inspected, and cultures are taken. In skilled hands the procedure takes no more than from fifteen to thirty seconds, and the patient suffers very little discomfort. If typical diphtheritic membrane is seen in the nose or throat or if the patient is obviously suffering from a mild, nonspecific infectious laryngitis, a diagnostic laryngoscopy need not be performed.

DIAGNOSTIC SUCTION

In some cases, even inspection of the larynx does not enable one to distinguish with certainty a diphtheritic from a nondiphtheritic infection. For example, in very early laryngeal diphtheria, the membrane may resemble the exudate found in nonspecific infections, and, on the other hand, a severe streptococcic or staphylococcic infection may produce a fibrinopurulent exudate resembling the membrane in diphtheria. In such instances, light, rapid suction may be applied and the exudate or membrane examined grossly and bacteriologically. Occasionally, membrane lining the subglottic region may be covered with mucus and resemble pale, swollen mucosa. After aspiration, inspection will usually reveal small pieces of membrane flapping back and forth with respiration, and the diagnosis will be made at once. In cases of doubtful diagnosis and of known or suspected sensitivity to serum, diagnostic suction may obviate dangerous and needless antitoxin administration. On the other hand, diagnostic suction is harmful in some instances and definitely contraindicated even though the etiology is uncertain. For example, in infants and in patients with considerable subglottic edema, aspiration may be followed by an increase in the edema resulting in complete stenosis of the already narrowed lumen. When cardiac or pulmonary complications are present, diagnostic laryngoscopy and suction should be omitted and antitoxin given at once. In patients who have already received a therapeutic dose of antitoxin, diagnostic suction, being of academic interest only, need not be done.

The technic of aspiration is described later in the paper under treatment. Whenever a patient receives laryngoscopy or suction for diagnosis or treatment, Chart I is used to describe the findings.

CHART I

NAME		DATE	A.M. P.M.
Time call sent in		Time of arrival of physician	
Temperature	Pulse		Respiration
Restlessness	Pallor	Cyanosis	Retractions
Heart			Voice
Lungs			
Laryngoscopy	Yes	No	(minutes)
General congestion			Visibility
Edema of epiglottis		Vocal cords	Color
Edema of aryepiglottic folds			Function
Edema of arytenoids			
Edema of false cords			
Stenosis of superior laryngeal aperture	Stenosis of glottic chink		Subglottic edema
Membrane visible	Yes	No	
Location			Color
Amount			
Exudate visible	Yes	No	
Location			Color
Amount			
Culture taken	Yes	No	
Intubation tube in situ	Yes	No	
Intubation tube—Remarks			
Extubation	Yes	No	Reason:
Suction	Yes	Number of times	No
Location	Amount and character of membrane		Amount and character of exudate
Larynx			
Trachea			
Right bronchus			
Left bronchus			
Relief obtained			
Restlessness	Pallor	Cyanosis	Retractions
Heart			
Lungs			
Temperature	Pulse		Respiration
Intubation	Yes	No	Size of tube
Relief obtained			
Restlessness	Pallor	Cyanosis	Retractions
Heart			
Lungs			
General remarks			
2 hours later	Temp.	Pulse	Resp.
4 hours later	Temp.	Pulse	Resp.
6 hours later	Temp.	Pulse	Resp.

BACTERIOLOGY

A single culture swab applied directly to the larynx during laryngoscopy was implanted upon two Löffler slants, and these were sent for examination to the laboratories of the New York City Department of Health and the Willard Parker Hospital. Reports were received from one or both laboratories in 178 out of the 261 cases in this series. In the remaining 83 cases laryngoscopy was unnecessary for diagnosis or treatment. Of the culture reports received from the laboratory of the Department of Health, 76 per cent were positive for the presence

of Klebs-Löffler bacilli, and 24 per cent were negative. Of the culture reports received from the laboratory of the Willard Parker Hospital, 79 per cent were positive and 21 per cent were negative. When the 24 per cent negative reports of the Department of Health were checked against the associated reports from the Willard Parker Hospital and the 21 per cent negative reports of the Willard Parker Hospital were checked against the associated reports from the Department of Health, it was found that in all but seven cases the other laboratory had given an associated positive report. In twelve other cases a negative report was received from one of the laboratories with no associated report from the other. However, in these nineteen cases, 11 per cent of the reported cases, there was clinical evidence of diphtheria, and cultures from the nose and throat showed Klebs-Löffler bacilli. This method of check-up between the independent laboratories shows that a single culture, although taken directly from the infected larynx, involves at least a 21 per cent margin of error. By the use of two laboratories, this error was reduced to 11 per cent. The danger of withholding specific therapy because of a negative report is, of course, generally recognized; moreover, the dependence for final diagnosis upon a single, even though direct, laryngeal culture should not be absolute. In 87 per cent of the patients, other organisms were found associated with the Klebs-Löffler bacilli. Of these, 70 per cent had *Streptococcus hemolyticus;* 35 per cent, *Streptococcus viridans;* 15 per cent, *Staphylococcus aureus;* 8 per cent, *Staphylococcus albus;* influenza bacilli were found in three patients; *Bacillus pyocyaneus* and pneumococcus Type VI (Bullowa-Cooper) in one each. No deductions as to modifications of the diphtheritic infection could be drawn from the presence of the different organisms.

TREATMENT OF DIPHTHERITIC CROUP

In general, the treatment can be divided into two parts, medical and operative, the latter consisting of aspiration, intubation, and tracheotomy. In the following section, an attempt will be made to give a detailed account of the treatment used at present at the Willard Parker Hospital. It will include the indications for the various procedures, their rationale, a description of the instruments used, the technic of their application, and the pitfalls and dangers involved.

MEDICAL TREATMENT

1. Diphtheria antitoxin containing 20,000 units is given, half intramuscularly and half intravenously, after a negative skin and conjunctival sensitivity test. An attempt is made, even in the youngest pa-

tients, to get the serum into the veins, in view of the observation by Tolle[13] that in patients in whom intravenous injection is used the membrane stops forming from twelve to twenty-four hours sooner than in patients in whom only the intramuscular route is used. In mild cases only 10,000 units need be given; whereas in toxemic patients, who have membrane on the tonsils, uvula, palate, and pharynx, markedly swollen cervical glands, and a strong diphtheritic odor, 30,000 or 40,000 units should be given, at least half intravenously.

2. The patient is put to bed in a cubicle 6½ feet square and 7½ feet high. A canvas covering is spread over the top and allowed to hang down over the open side, almost completely enclosing this space. An electric stove heats a kettle to supply steam. The warm, moist air apparently soothes the inflamed mucous membrane of the respiratory tract, and the tent also has a beneficial psychologic effect upon the patient, nurses, and doctors. Compound tincture of benzoin may be added in a dilution of one dram to a quart of water, but too great a concentration, such as results when the water evaporates, may irritate the respiratory tract and cause coughing.

3. A liquid diet is given and fluids pushed. Many of these children refuse all food and may require gavage and clyses. Gavage feedings can be given very quickly and often with less disturbance to the patient than forced mouth feeding. In infants who are unable to suck due to respiratory difficulty, feeding should be attempted by the Breck feeder, spoon or medicine dropper, before resorting to gavage. When severe coughing paroxysms are caused by mouth feeding, gavage is indicated to prevent further laryngeal irritation.

4. A soapsuds enema is given routinely on admission and daily, if necessary.

5. Whisky, one dram per year up to half an ounce, is diluted with water and sugar and given every three hours. This is used for its sedative effect. Swallowing of the whisky is often followed by short paroxysms of coughing and thus may aid in bringing up obstructive membrane. In some cases, it causes vomiting and should be discontinued. If asleep, the patient should never be disturbed for such medication.

6. With the whisky, syrup of ipecac is given, 10 minims to a dram depending on the age, every three hours. Its action as an expectorant may perhaps help separate the membrane. Should vomiting occur, the ipecac is stopped.

7. When there is profuse nasopharyngeal discharge, it is removed by suction with a soft rubber catheter. This is followed by instillation of ephedrine in oil.

8. When the temperature is over 102.5° F., an ice cap and alcohol sponges are given. If the temperature is very high, antipyretics and

cold colonic irrigations are added. Lowering the fever results in a decrease in the metabolic rate and in the oxygen requirements, with the result that retractions diminish; respiration slows down; and there is less need for mechanical intervention.

9. If the cervical glands are enlarged, an ice collar or a flaxseed poultice is applied.

10. Since restlessness is the most important and constant warning sign of increasing obstruction and anoxemia, strong sedation is to be avoided for fear of inhibiting this valuable index. In one hospital, a patient later transferred to us was actually given chloroform because of extreme restlessness resulting from anoxemia. Strong sedation is especially dangerous at night when cyanosis is more difficult to detect and the absence of restlessness may prevent a nurse from recognizing the seriousness of the child's state. When these facts are borne in mind, sedatives like codeine, luminal, and bromides may be used with caution to insure complete rest and allay excessive and nonproductive coughing.

11. Stimulants are used as indicated in special cases.

OPERATIVE TREATMENT

When there is enough stenosis to require mechanical intervention, there are three procedures at our command, namely, aspiration, intubation, and tracheotomy, in the order named. Until the possibilities of aspiration have been exhausted, intubation is not performed, and tracheotomy is resorted to only when the use of aspiration and intubation has failed or has been deemed inadvisable.

The indications for intervention at any time, regardless of the procedure to be used, are as follows:

Signs of extreme obstruction

1. Restlessness
2. Cyanosis—pallor
3. Deep retractions
4. Absent breath sounds
5. Anxious facies

Signs of exhaustion

1. Tachycardia, impalpable pulse, heart failure
2. Tachypnea—rapid, shallow breathing
3. Hyperpyrexia—from 105° F. to 107° F.
4. Stupor—coma—convulsions

Each child shows signs of anoxemia in its own peculiar manner, usually the same each time. Therefore, the signs of obstruction in any case must be evaluated individually in order to determine the most suitable time to intervene.

Aspiration

History.—Before the application of suction, the removal of obstructing laryngeal and tracheal membrane was attempted by means of swabsticks and several types of forceps. These were not often successful, particularly when the membrane extended a long way down the trachea. In 1916 Lynah[8] reported a series of cases treated by suction through a bronchoscope. In 1923 Gover and Hardman[14] working at the Willard Parker Hospital reported a series of cases treated by suction with elastic catheters, and in 1930 Tolle,[13] also at the Willard Parker Hospital, reported a large series, in which she used metal suction tubes. This method is being used at present.

Instruments.—Chevalier Jackson type laryngoscope, infant and child sizes, with extra lamp-carriers and bulbs. Dry cell batteries with rheostat attachment. Six feet of flexible cable. Swabsticks 8 inches long with cotton wool tips firmly attached. Hemostats to grasp sticks. Tongue depressors. Willard Parker metal laryngeal suction tubes attached to an electric suction pump fitted with a wash bottle by 3 feet of stout flexible rubber tubing. Basin of warm water for flushing purposes.*

Technic.—The patient is securely "mummied," and the shoulders are placed over a sandbag, 4 inches thick. The head is extended quite far back, but not too far, in the Boyce position, and a nurse standing on the right of the patient steadies the head in the midline by placing her hands on either side against the ears and temples. Another nurse restrains the knees. The room should be in semidarkness. The operator wearing a mask and goggles sits on a stool at the head of the table and performs a direct laryngoscopy. While the laryngoscope is being held in the left hand, he takes the suction tube, attached to the suction pump, in the right hand, and holding it lightly between the thumb, index, and middle fingers gently directs it through the laryngoscope. When there is abundant membrane covering the supraglottic structures and obscuring the vocal cords, the tip of the suction tube is gently applied to these areas and the membrane removed. The degree of underlying edema can now be estimated, and with the superior aperture thus cleared the cords can be studied as to swelling, color, and function. The tube is then flushed and passed into the trachea just as the vocal cords separate. This can be seen or timed with the inspiratory effort. No attempt should be made forcefully to overcome the spasm which usually occurs on contact with the instruments, but one should wait

*These may be obtained from the Tieman Company, East Twenty-Eighth Street, New York City, or from the G. P. Pilling Company, Philadelphia, Pa. Recently the latter have made up a special suction tube, under our instructions, with a curved, flexible, spiral tip to enable us to aspirate the primary bronchi with greater certainty.

for the opening of the glottis, which the trained hand will readily recognize by the sudden "give" as the child takes a deep breath. Before the tube is passed below the cords, especially when the supraglottic structures are quite edematous, it is better to stop the pump, because otherwise the tissues will be drawn into the tip of the suction tube, making its passage more difficult and causing needless trauma in the attempt. As soon as the cords are passed, the pump is started again, and the tube is slowly directed down the trachea, as far as the bifurcation if necessary, and then slowly withdrawn, the suction being continued during all this time. The aspirating tube need not remain

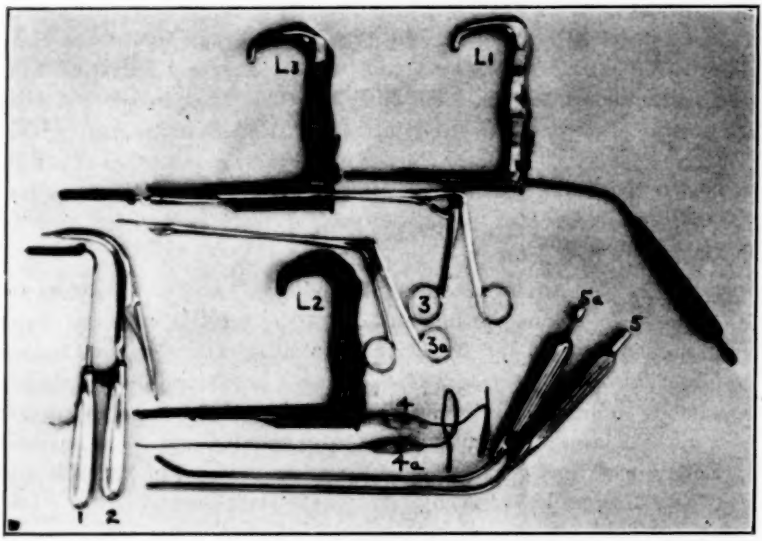

Fig. 1.—Instruments used in the suction and intubation treatment of croup. *1*, O'Dwyer intubator; *2*, O'Dwyer extubator; *3* and *3a*, Direct (visual) intubators; *4* and *4a*, Large and small direct (visual) wire extubators; *5* and *5a*, Willard Parker suction tubes, straight and curved tips; *L1*, *L2*, and *L3*, Jackson laryngoscopes No. 6, 12, and 14.

in the trachea more than four or five seconds. In cases with considerable tenacious membrane this may have to be repeated once or twice, flushing the tube between times. When it is felt that one or both of the main bronchi are plugged with membrane, we use a specially constructed tube with a curved flexible spiral tip. With this instrument either one or both bronchi can be surely and quickly cleared.

Indications.—Good judgment in deciding when to intervene can be attained only after much experience and is more elusive than the acquisition of mere mechanical skill.

In the first place, aspiration should be performed only when there is

something to be removed, such as membrane or mucopurulent exudate, which is causing the obstruction. It should not be attempted when the stenosis is due only to edema because in the latter condition no benefit will be derived and grave damage may be caused.

The general indications for mechanical intervention of any kind have been given above. These should be borne in mind to avoid the usual tendency to use suction more often than is really necessary. If a young child is sleeping and his color is good, intervention is not warranted, even though retractions are deep and the breath sounds are diminished. At this stage, many children will cough up the obstruct-

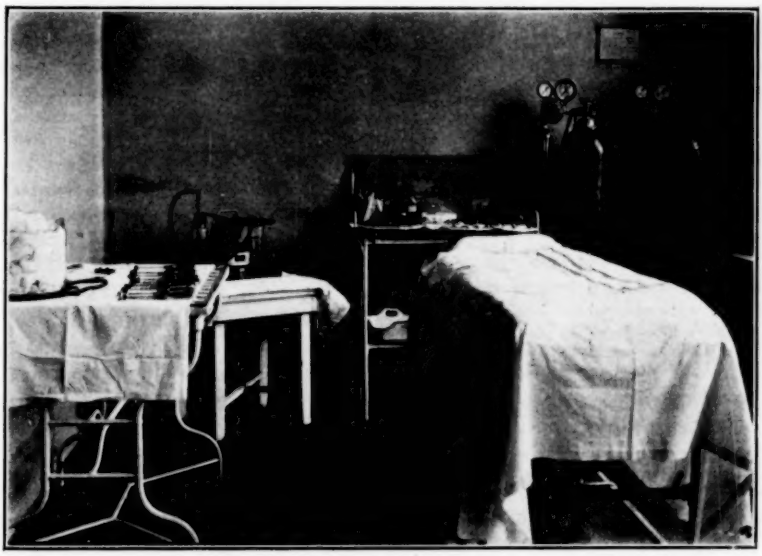

Fig. 2.—General layout of operating room for treatment of a case of croup.

ing membrane if given an expectorant and some whisky, or merely some cold water, and suction will thus be avoided. On the other hand, one should not wait too long and let the child exhaust himself before giving him relief. This delay is apt to occur especially during the night when nurses may be inclined to let the doctor sleep a little longer.

As a general rule, strong children may be allowed to "pull" longer than those with rather frail constitutions. In dealing with the latter, and also with toxic patients, it is advisable to intervene earlier to avoid the risk of exhausting them.

Although restlessness is almost always the best index to a patient's condition, in rare instances a child may be so toxic, stuporous, and

exhausted that restlessness does not occur and retractions may be minimal. The color is ashy pale, slightly cyanotic, and breath sounds are greatly diminished. It is easy to see how such cases can be overlooked at night.

Occasionally, one bronchus may become plugged with membrane, as evidenced by a marked diminution or absence of breath sounds over one side of the chest. The other lung may be aerated so well that there is no anoxemia. In such cases, it is wise to aspirate the membrane from the plugged bronchus at once in order to prevent the development of atelectasis and possibly pneumonia.

The following is an illustrative case.

A baby boy, ten months old, was admitted on the fourth day of illness. Membrane was seen on the pharynx and tonsils, and the child was moderately dyspneic and hoarse. Antitoxin was given, but no laryngoscopy was done. Eighteen hours later, his temperature rose to 104.6° F. and his respirations to sixty a minute. An examination of the chest showed only moderate retractions, but the left lung was dull with high pitched breath sounds. No râles were heard. The apex beat was one inch outside the nipple line. A diagnosis of collapse of the left lung was made. This was confirmed by roentgen-ray examination, which showed a collapse of the left lung, a shifting of the mediastinum to the left and a narrowing of the left intercostal spaces. Laryngoscopy showed membrane on the aryepiglottic folds and moderate subglottic edema. The curved suction tube was directed into the left bronchus and several pieces of membrane together with some plugs of mucopus were removed. At once, breathing became easier, breath sounds louder and the percussion note nearly normal over the left side of the chest. A roentgenogram showed a shifting of the mediastinum to its normal position.

In early cases of diphtheria, suction should be avoided if possible because removal of the thin adherent membrane may be followed by increased swelling of the tissues, sometimes necessitating early intubation which might otherwise have been avoided.

The following case is an illustration.

A fifteen-month-old baby boy was admitted on the second day of illness with a moderate amount of stridor, slight retractions, and some hoarseness. Breath sounds were moderately diminished over the entire chest. Membrane was seen on both tonsils. Antitoxin was given and the child put to bed. Eight hours later, the child became restless; retractions were somewhat deeper; and respirations rose to sixty a minute. A laryngoscopy, by a junior resident, revealed moderate supraglottic and subglottic edema, but no membrane was seen. Suction was applied and several large pieces of thin membrane were removed. This gave considerable relief, but an hour and a half later the child became extremely restless and slightly cyanotic, with almost complete suppression of breath sounds; the temperature rose to 106° F. Laryngoscopy revealed extreme subglottic edema necessitating an immediate intubation, which gave complete relief at once. The fever dropped to 101° F. one hour after the intubation. Four days later, the tube was coughed up. Two weeks later, the child developed widespread bronchopneumonia from which recovery was slow. He was discharged cured on the fifty-second day of illness.

In some early cases, however, the membrane may be quite thick, and then it can usually be removed with impunity. The following case is typical.

A fifteen-month-old baby girl was admitted on the second day of illness. She had severe respiratory distress and deep retractions. Breath sounds were nearly absent. Both tonsils were covered with membrane. Laryngoscopy showed moderate congestion and edema and membrane upon and between the vocal cords. Suction removed five pieces of membrane from 3 to 4 cm. long. The child was completely relieved and dropped off to sleep at once. She needed suction again in fourteen hours, with the removal of a complete tracheal cast with bronchial branches, then in six hours, ten hours, six hours, five hours, four hours, and again in four hours. During this time, less and less membrane was being obtained, and the subglottic edema was increasing progressively, so that finally intubation had to be performed. This gave complete relief. Five days later the tube was removed, and the child was discharged cured on the twentieth day of illness.

Rarely, the insertion of the laryngoscope may cause sudden, probably reflex, cessation of respiration with cyanosis and unconsciousness. If inspection shows the presence of membrane, the apnea should be disregarded, laryngeal and tracheal suction quickly performed, and artificial respiration and oxygen given at once. Adrenalin, which should always be on hand for just such emergencies, should be given subcutaneously. The patient will nearly always recover. On the other hand, failure to use suction at once before giving artificial respiration may prove fatal. The following case is a typical illustration.

A baby girl, two years old, was admitted on the third day of illness with severe respiratory distress. On introduction of the laryngoscope, the child stopped breathing, turned blue, and lost consciousness. Aspiration was quickly performed and a large amount of membrane, including a complete tracheal cast, was removed. Adrenalin was given while the child was getting artificial respiration. The child revived, breathing easily. After thirty-three hours, she required suction again, once more with the removal of a complete tracheal cast and many smaller pieces of membrane. She had an uneventful recovery and was discharged cured on the fourteenth day of illness.

By this method, many children admitted to the hospital thrashing about, with deep retractions, the sternum fairly meeting the vertebral column with each inspiration, with absent breath sounds, with cyanosis or ashy pallor, have been relieved in a minute or two and have fallen asleep on the table, even before the laryngoscope was removed, the retractions gone, the breathing easy, and the color pink. Some of the children were seen gasping fishlike or even not breathing at all, unconscious, practically dead, and have been restored to life after an immediate rapid suction of the air passages and the institution of artificial respiration. Two children manifested the first signs of returning life by generalized convulsions which passed off in from three to five minutes. These two cases are typical.

An eight-year-old boy was brought to the hospital on the sixth day of illness. No diphtheria antitoxin had been given. On admission, he was deeply cyanotic and

gasping weakly. During laryngoscopy, the child stopped breathing, but suction was quickly performed and a large laryngotracheal and probably bronchial cast 12 cm. long and 1 cm. wide, was removed. Artificial respiration was begun while adrenalin was given under the skin. The heart sounds were very weak. After a minute or two of artificial respiration, he developed generalized convulsions lasting about three or four minutes. Then his color returned; breathing became easy; and breath sounds were well transmitted all over the chest. There was marked fetor oris; membrane was seen in the nose, on the pharynx, tonsils, and uvula; there was considerable cervical adenopathy on both sides. The patient was given 40,000 units of diphtheria antitoxin, half intramuscularly and half intravenously. Eight intravenous injections of 100 c.c. of 30 per cent glucose were given subsequently. Twenty hours later and again thirteen hours later suction was used, each time with the removal of a large amount of membrane and with complete relief. Convalescence was slow but uneventful except for the occurrence of occasional premature ventricular contractions. He was discharged cured on the sixty-second day of illness. When seen a year later, he was in excellent health, had good heart action, and a strong, clear voice of normal pitch. There had been no recurrence of croup.

A four-year-old boy was brought in on the fifth day of illness. No diphtheria antitoxin had been given prior to admission. On admission he was extremely cyanotic, thrashing about, arms outstretched, with an anxious, pleading look, completely aphonic, with very deep retractions, and breath sounds absent all over. Laryngoscopy revealed marked congestion and moderate edema, and membrane completely plugging the glottis. By suction, a large amount of membrane and mucopus was removed, giving complete relief, the child falling asleep on the table. The nose, pharynx and tonsils were clean. This type of case is often called primary laryngeal diphtheria, but there was a history of a running nose and a sore throat five days before admission and hoarseness two days later. He was given 30,000 units of antitoxin, half intramuscularly and half intravenously. The child needed suction again in twelve hours and once more fifteen hours after that. Each time large amounts of membrane were removed with complete relief. He was discharged on the twentieth day of illness after an uneventful convalescence.

The interval between application of suction varied between a half hour and three days, depending upon the rapidity of new membrane formation, the clogging of the larynx by loosened membrane coughed up from below, and the varying degree of subglottic edema present. The average number of suctions performed in nonintubated cases in which the patient recovered was 2.1. The average in Group I was 1.4; in Group II, 2.0; and in Group III, 4.2. None of these patients required suction more than five times. For complete data, see Table I giving general results.

The advantages over previous methods are manifold. In skilled hands, suction is practically harmless. The dangers of routine, haphazard intubation when membrane or mucopurulent exudate is present are obvious; the membrane may be pushed down or may plug up the tube causing immediate asphyxia.[15] O'Dwyer[12] said, "Pushing down membrane before the tube is the most serious of the unavoidable accidents attending intubation." Other methods of removal such as by swab sticks, long forceps, and O'Dwyer's expanding-tube forceps have

fallen into discard for obvious reasons. Silk-woven catheters have been found less effective than metal tubes. This method does away with bronchoscopy because the main bronchi can easily be reached by the suction tube, and there is no particular need to see them. The dangers of bronchoscopy are not present here. This method is less cumbersome, more rapid, less liable to traumatize, and can be repeated more often with much less danger to the patient. The operation, if properly done, upsets the patient only slightly. Not only is it not dreaded, but some older children have actually asked for it the second or third time and thanked the operator after it was over. There is usually no bleeding at all or only some slight, transient, insignificant oozing, unlike the profuse bleeding sometimes resulting when membrane is removed from the nose. In unskillful hands, the procedure is not without danger, and it should never be done except in the presence of an experienced person. In infants particularly, the parts may be traumatized and a false passage may be formed by forcibly pushing the tube sideways through the ventricle. The latter accident we have never seen. It is a common error for beginners to pass the tube into the esophagus, instead of the larynx. Before the technic of direct laryngoscopy is thoroughly mastered, suction should not be attempted.

In some cases of laryngeal diphtheria, a single suction immediately transforms a complete aphonia into a clear voice, whereas in others hoarseness persists for weeks. The latter is not due to the instrumental treatment, but to the disease, since we have seen persistent hoarseness in many children who have not received suction.

When the smaller bronchi are involved, no type of instrumentation is really effective. Many unnecessary tracheotomies have been performed, and still are, with consequent needless morbidity and mortality. In the cases cited above, the performance of a tracheotomy would have consumed more valuable time and would have caused greater shock to the patient, making the outcome much more doubtful.

The following case is cited to illustrate the use of suction and avoidance of intubation in an infant.

A six-month-old male infant was admitted on the fourth day of illness. No antitoxin had been given. He was acutely ill, moderately hoarse, and had deep retractions. Breath sounds were greatly suppressed throughout the chest. Membrane was seen on the tonsils and in the nose. Laryngoscopy showed moderate edema and congestion above the vocal cords and membrane plugging the glottis. After this was removed by suction, the subglottic region was found to be more than moderately edematous. The child was completely relieved at once. He needed the suction treatment again in twelve hours, again in four hours, and once more in fifteen hours. During the last suction, only a small amount of membrane was obtained, and the relief was only moderate because of the increasing subglottic edema. At that time, it was believed that intubation would be absolutely necessary. One hour after the last suction, the child became very restless, had deep retractions, moderate

pallor and slight cyanosis. Laryngoscopy showed extreme subglottic edema and a shred of membrane. This was removed by suction and then the tip of the open suction tube was held for fifteen seconds in the subglottic region, with the suction pump turned off. This was done with the hope that intubation might be avoided. Unexpectedly, it was successful, and the infant recovered without any complications and was discharged cured on the eighteenth day of his illness.

In this case, we resorted to unusual measures because very young infants do poorly after intubation. This child, when seen a year later, was in perfect health and had a strong, clear voice.

Intubation

History.—Catheterization of the larynx for cases of stenosis is mentioned in the writings of Hippocrates, but is not heard of again until 1780 when Chaussier proposed its use in the asphyxia of the newborn and in obstruction due to disease. This method was used with some success in adults by Dissault in 1801 but was found impracticable in children because of the protrusion of one end of the tube through the nose or mouth. In 1858 Bauchut demonstrated that the larynx could tolerate a tube and advocated intubation for laryngeal obstruction. The procedure was condemned in Paris as not good enough to supplant tracheotomy until 1885, when O'Dwyer first introduced suitable instruments. Since then, its use has been widespread and successful. Lynah in 1914 devised the so-called non-cough-up tube.

Rationale.—The purpose of intubation is to provide an artificial airway by placing a rigid tube within a stenosed laryngotracheal lumen. The narrowing occurs in one or more of three possible locations, namely, the supraglottic region due to edema of the epiglottis, aryepiglottic folds, the arytenoids, and the false cords; the glottic region due to edema of the vocal cords, less often to adductor spasm or abductor paralysis; and lastly, and most commonly, the subglottic region due to edema and infiltration of the loose areolar tissue at this site.

Technic.—Intubation may be performed under direct vision through a laryngoscope or by the indirect, tactual method of O'Dwyer.

Visual Method.—Instruments used are a number 12 or 14 or adult-size Jackson type laryngoscope and a direct intubator, several of which are available on the market. The larynx is visualized, and the tube is inserted with the flange facing downward, care being taken that the tube does not slip off the intubator lest it be swallowed since no string is attached to it. When the number 12 laryngoscope is used, the lower segment of the barrel may be removed in order to provide more working room. A common beginner's error is to insert the tube into the esophagus. It is needless to add that direct intubation should be done only by one who has mastered the art of direct laryngoscopy.

Tactual Method.—Instruments used are an O'Dwyer intubator, a mouth gag and a pair of scissors. The child is "mummied" and placed flat on the table, no sandbag being used. A nurse, standing at the head of the table, extends the head and steadies it in the midline. The mouth gag is inserted, but the mouth is not opened until the operator, standing at the patient's right, has the intubator in readiness. He then inserts the index finger of his left hand down to the epiglottis, which is easily recognized in older children by its semicartilaginous feel, but may be difficult to distinguish in infants under a year, and pulls that structure toward him so that the tip of his finger is just over the glottis. Then the intubator, held in the right hand, is inserted so that the tube is placed between the finger and epiglottis. As the tip of the tube reaches the tip of the finger, it is directed anteriorly and inserted into the glottis. The string, which is attached to the tube and wound about the right index finger, is now allowed to slip from the finger and the tube is pushed down with the left index finger until the flange rests upon the arytenoids posteriorly. When the tube is in its proper place, the child usually coughs and breathes with a metallic sound; then, after about from thirty to sixty seconds, retractions disappear and breathing becomes easy. If the tube is not pushed down far enough, coughing persists for a long time and the tube is finally coughed up, or the child may become suddenly cyanotic and very dyspneic. After the intubation the string is cut and removed while the tube is held in place by the left index finger. This prevents gagging, coughing, and vomiting in many cases. In some patients in whom sudden and repeated blocking is occurring, the string may be left attached for immediate extubation by a nurse. The most common error in intubation is to insert the tube into the esophagus. This is especially apt to occur in very young children in whom the epiglottis is small and difficult to define, in patients whose larynx is very far forward, and in children who gag repeatedly and draw the larynx downward and forward. If the tube is misplaced into the esophagus, the dyspnea will not only be unrelieved, but will usually become even worse. The stridor and cough will not have a metallic quality and the string may become shorter as the tube passes down the esophagus.

At the Willard Parker Hospital the tactual method has been the method of choice, especially in emergencies, because it takes less time in preparation and it precludes lighting contingencies. When laryngoscopy shows a need for immediate intubation, the visual method may be used. In cases of laryngeal anomaly, intubation by direct vision is preferable. In adults, tactual intubation is made difficult because of the great distance between the teeth and the epiglottis and because intubation with the aid of a laryngeal mirror is too cumbersome and uncertain.

In skillful hands the dangers of intubation by either method are more theoretical than real. It is conceivable that a false passage might be formed either along the outside of the larynx or through its wall or that the tube might be pushed too forcibly beyond the vocal cords. We have witnessed only one accident. In this case, an inexperienced operator, forcing the tube through one of the ventricles, lacerated the vocal cord and tore through the wall of the larynx.

Indications.—In diphtheria the only indication for intubation is extreme subglottic edema. This usually appears as part of the local reaction to the infection but may sometimes develop following the repeated removal of membrane by suction.

Intubation fails to give relief if there is membrane present blocking the lower end of the tube. As mentioned above, this used to be a common cause of immediate asphyxia. For this reason, intubation is preceded by suction whenever the presence of membrane is suspected. When there is too much edema above or below the ends of the tube, intubation is obviously ineffective. However, this condition has not been met with in our experience with diphtheria. The following case illustrates intubation without suction.

A male child, two years old, was admitted with a history of cough and fever followed by difficulty in breathing during the night preceding admission. On admission the next morning, he was pale, moderately cyanotic, aphonic, and had loud stridor with deep retractions. Breath sounds were absent over the entire chest. There was membranous exudate on both tonsils. Laryngoscopy showed moderate congestion and edema on the supraglottic structures, but no membrane or exudate. The glottis was narrowed, and the subglottic edema was so extreme that only the narrowest slit for the passage of air could be seen. No membrane or exudate was present. Suction was considered useless; therefore, the child was intubated with a size one-year tube. Relief was immediate and complete. The history and the largyngoscopic examination suggested the likelihood of a nondiphtheritic infection. However, this was not a certainty since early diphtheritic infections often resemble those due to the streptococcus or staphylococcus. Although antitoxin had already been given before admission, another injection of 10,000 units was given intramuscularly. (Culture reports from both laboratories later showed Klebs-Löffler bacilli in the nose, throat, and larynx.) The tube was coughed up three times and was not replaced after the last time. At no time was membrane seen in the larynx or trachea. The child was discharged on the fifteenth day of illness after an uneventful convalescence.

Complications of Intubation: Blocking of Tube.—A. *By Membrane:* This may be coughed up from below and may lodge in the tube or plug up the end causing sudden asphyxia and necessitating immediate extubation followed by suction and, in most cases, by reintubation.

A three-year-old boy was admitted on the seventh day of illness. No diphtheria antitoxin had been given. The child was acutely ill, very pale, completely aphonic, with very labored breathing, and deep retractions; breath sounds were absent over the entire chest. Laryngoscopy showed membrane on the epiglottis, aryepiglottic

folds, vocal cords, and in the glottis. Aspiration obtained many pieces of membrane and gave complete relief. It was noted that there was more than a moderate amount of subglottic edema. The patient was given 30,000 units of antitoxin, half intramuscularly and half intravenously. After twelve hours, he became very restless; he had deep retractions, and breath sounds were greatly suppressed. Laryngoscopy revealed extreme subglottic edema, and suction obtained only a few shreds of membrane and gave only slight relief. After ten minutes, dyspnea became so severe that intubation had to be performed. This gave complete relief. Twenty-four hours later the child suddenly became cyanotic, restless, and markedly dyspneic. Laryngoscopy showed the tube blocked by membrane. The tube was removed, and laryngeal and tracheal suction was performed, with the removal of many pieces of membrane. This gave immediate, complete relief, but after thirty-five minutes increasing dyspnea required reintubation. This procedure was repeated in nine hours. Twenty-four hours later, the tube was coughed up and found partly blocked. Suction removed a moderate amount of membrane, but gave only transient relief, intubation being required in fifteen minutes. This event was repeated in twelve hours. Three days later the tube was removed, and the child had an uncomplicated convalescence. He was discharged cured on the twenty-third day of illness. One year later the child showed no abnormality except a somewhat low-pitched voice.

B. *By Exudate:* This is a less common feature in diphtheria and is due to the sticking of dried secretions in the tube. It usually occurs gradually and is accompanied by progressively increasing dyspnea. Extubation should be performed before asphyxia occurs. Ipecac may be given as an expectorant, and fluids should be forced to prevent rapid drying.

A three-year-old girl was admitted on the third day of illness. No antitoxin had been given. On admission she was acutely ill, ashy-pale, restless, hoarse, and markedly dyspneic. Breath sounds were greatly diminished throughout the chest. The heart was rapid, forceful, and there was a loud systolic murmur at the apex transmitted to the axilla. (There was a history of rheumatic fever with cardiac involvement.) The tonsils were enlarged and covered with membrane. Laryngoscopy showed moderate congestion and edema of the supraglottic structures and the glottis filled with membrane. Aspiration removed many thick pieces of membrane and revealed marked subglottic edema. The child was relieved only slightly. She was given 30,000 units of antitoxin, half intramuscularly and half intravenously. An hour later, she became restless with deep retractions and slight cyanosis. Intubation was performed with a size two-year tube, and she was completely relieved. Forty-eight hours later she suddenly stopped breathing and became extremely cyanotic and pulseless. Laryngoscopy showed the entire larynx obscured by profuse mucopurulent exudate. After preliminary suction to expose the larynx, the tube was removed and found to be blocked by mucopus. Then, laryngeal and tracheal suction removed several pieces of membrane and considerable mucopus. She was reintubated and artificial respiration was begun. After about a minute, the child began to gasp between long periods of apnea. The heart beat forcefully. Her color gradually improved, and her breathing returned to normal. Twenty-four hours later during a gavage she had a violent fit of coughing, and her breathing suggested the probability that the tube had been coughed up part of the way. Laryngoscopy confirmed this. The tube was removed and found partly blocked with stringy mucopus. Suction of the larynx and trachea obtained several shreds of membrane and many plugs of mucopus. She was not reintubated until nine hours later when her dyspnea

became quite severe. Three days later the tube was removed, and the child recovered without developing any complications. She was discharged on the twenty-third day of illness. On follow-up a year later, the child had a normal voice and was in good general health despite the old cardiac condition.

C. *By Edema:* Rarely, supraglottic edema may increase and overlap the upper opening of the tube, necessitating a tracheotomy. No such case occurred in our series.

Cough-Up of Tube.—This usually occurs when the edema around the tube has subsided, so that the child often does not have to be reintubated, although retractions may persist for a day or two. Blockage of the tube by membrane or exudate may induce a cough strong enough to dislodge the tube even when the edema is severe enough to necessitate immediate reintubation. Tubes are most often coughed up shortly after gavage and may be swallowed. The reason for this probably is that gagging and vomiting cause relaxation of the glottic tissues, allowing the tube to be expelled very easily. If the tube cannot be found, for it may be swallowed, the type of breathing will often indicate that it has been coughed up. If the tube is coughed up within about fifteen minutes after being inserted, it is most likely due to the intolerance of the larynx and trachea to the foreign body. However, if it is coughed up later, it is usually due to an accumulation of exudate or membrane below or within the tube. After the tube is coughed up, the lumen remains patent for a varying period, during which the patient shows very little distress. However, after this time, which may last from only a minute to an hour or a day or more, the patient may grow progressively more dyspneic or may collapse suddenly requiring immediate reintubation. When the tube is coughed up too often, reintubation with a larger tube may remedy the difficulty. Non-cough-up tubes, with a bulge at the lower end, are no longer used here because of their tendency to cause pressure necrosis.

The following case is an illustration:

A two-year-old boy was admitted on the third day of illness. He was given antitoxin on that day—8,000 units intravenously, 10,000 units intramuscularly. He was acutely and desperately ill, restless, very pale and slightly cyanotic, aphonic, and in great respiratory distress. Breath sounds were absent. Laryngoscopy showed moderate congestion and edema of the supraglottic structures with bits of membrane attached to the vocal cords. Suction removed several pieces of membrane and much mucopus, revealing considerable subglottic edema. There was a moderate degree of relief for ten minutes, then the dyspnea increased to such an extent that the child was intubated with a size one-year tube. This gave immediate, complete relief and the child fell into a deep sleep on the table. He was given 10,000 units of antitoxin intravenously and was put to bed. Eleven hours later the tube was coughed up, and within fifteen minutes breathing became labored. Suction removed several shreds of membrane. The subglottic edema was still extreme and the suction gave only temporary relief. He was intubated with a size one-year tube and was relieved

completely. This occurrence was repeated eighteen hours later, sixteen hours later, and again in twelve hours. The last time a size two-year tube was used. Twenty-two hours after that the tube was again coughed up but did not have to be put back for twenty hours. Four days later a trial extubation was performed, but after twenty minutes the dyspnea became so great that reintubation was necessary. The next day the tube was coughed up and did not have to be put back. Except for a moderate degree of bronchopneumonia in the right upper lobe, convalescence was uneventful, and the child was discharged on the twentieth day of illness.

Chronic Tube Cases.—These are cases in which repeated trial or autoextubation (by cough) are followed by resumption of respiratory distress necessitating reintubation. In the past, this condition was allowed to continue for months and even years and was finally overcome by tracheotomy. However, these patients were left with lifetime, marked vocal impairment resulting from pressure necrosis, granulations, and scarification of the vocal cords. Such a situation has not been allowed to develop during the past ten years. If after three weeks a child is unable to breathe without a tube, tracheotomy is performed, and the intubation tube is removed. Out of the 727 cases of croup, in which there were forty-eight intubated patients who recovered, no patient had to be tracheotomized for this cause. Thus, our experience differs from that of some other workers[16, 17, 18] who advise tracheotomy if after four or five days' trial extubation is unsuccessful.

The following case is one in which tracheotomy was narrowly avoided:

A fifteen-month-old baby girl was admitted on the third day of illness. No antitoxin had been given. On admission she was acutely ill, pale, slightly cyanotic, breathing with loud stridor and deep retractions, with breath sounds practically absent over the entire chest. Membrane was seen on the right tonsil. Laryngoscopy showed moderate congestion and swelling of the supraglottic structures and membrane plugging the glottis. Aspiration removed several medium-sized pieces of membrane, from 1 to 2 cm. long, revealing considerable subglottic edema. Following suction, breathing was easy, and the child fell asleep on the table. However, after fifteen minutes, dyspnea increased so that she had to be intubated with a size one-year tube, which gave complete relief. Five days later, a trial extubation was performed, but after five minutes she had to be reintubated. This time a size nine-month tube was used. After eighteen hours it was coughed up and had to be replaced within fifteen minutes. Four days later, on the morning rounds, the child was seen to be slightly restless and retracting moderately, but the color was good. The type of breathing suggested that the tube had been coughed up. A careful search was made, but the tube could not be found. Laryngoscopy confirmed our suspicions. She was reintubated and completely relieved. Roentgen-ray examination showed the tube in the abdomen, and it was later recovered by the nurse. A day later, the tube was coughed up again and had to be replaced in twenty minutes. Four hours later it was coughed up again. This time a size one-year tube was inserted. Five days later, a trial extubation was done, but after one hour the

dyspnea became so marked that the tube had to be replaced. At this time a tracheotomy was being contemplated because of the inability of the child to breathe without a tube. Two days later, eighteen days after the first intubation, the tube was coughed up again, and the breathing, though obstructed, was not difficult enough to require intubation. The patient had an uneventful recovery and was discharged on the twenty-ninth day of illness.

Aspiration Pneumonia.—It is the authors' belief that the presence of the tube increases the chances of aspiration. It prevents proper closure of the upper laryngeal aperture during deglutition and by covering over the laryngotracheal mucosa diminishes the cough reflex. For this reason, it is our practice to feed all intubated patients by nasal gavage. This, of course, does not eliminate the possibility of aspiration following vomiting.

Pretracheal abscess has been reported, but has not occurred in our series.

Extubation

Technic.—1. *Tactual:* This is done by digital palpation by means of the O'Dwyer extubator, the process being the reverse of tactual intubation. The tip of the extubator is inserted into the tube, and then pressure on the handle causes a separation of the two prongs of the tip. These grip the inside of the tube and permit it to be withdrawn easily. The lack of visual control in this method makes for uncertainty and increases the hazard. The tube may be pushed down below the vocal cords or the tissues may be traumatized if the prongs are separated between the tube and the laryngeal tissues. For these reasons, our method of choice is the direct, visual method next described.

2. *Visual:* This method, although requiring a laryngoscopy, is performed simply, quickly and harmlessly. The hooked or curved end of a long, firm wire (Fig. 1) is passed through the lumen of the tube, catches the rim at its distal end, and withdraws it quickly and surely. After this the larynx can be studied and suction applied if necessary.

Following extubation, patients often have to be fed by gavage for a day or longer because of severe coughing and refusal to take food.

Indications.—1. *Emergency extubation* is performed when the tube is blocked.

2. *Trial extubation* is performed when there is reason to believe that the edema has subsided sufficiently to enable the child to breathe without the tube. After the tube has been in place four or five days, if the temperature is normal and the child's progress is satisfactory, we feel that the time is favorable for extubation. This is done preferably in the morning, when the laryngitis is usually less severe

Contrary to the frequently expressed opinion, the need for intubation over a longer period than four or five days is no cause for undue apprehension. Food is withheld for three hours, and some codeine is given about one-half hour before the extubation is to be done. The elimination of vomiting and undue excitement lessens the respiratory distress and in some cases, no doubt, does away with the necessity for reintubation which might otherwise be required. Following extubation, the child should be pacified in every way possible. Severe respiratory distress, which may nevertheless ensue, is often transient and does not always call for immediate reintubation. If the children are carefully watched with this in mind, many of them can be tided over several stormy hours and reintubation avoided. If, however, reintubation is found unavoidable, the use of a smaller tube may be followed later by a permanently successful autoextubation.

A colored boy, two years old, was admitted on the sixth day of illness. No antitoxin had been given. He was underdeveloped, undernourished, acutely ill, had a poor color, was aphonic, and had extremely labored breathing with deep retractions and markedly suppressed breath sounds. There was a serosanguinous nasal discharge and there were patches of membrane on the tonsils. Laryngoscopy showed considerable congestion and edema of the supraglottic structures and membrane plugging the glottis. Suction removed many small pieces of membrane and tenacious mucopus; following suction the subglottic region was seen to be extremely edematous. The child rested comfortably for about five minutes, then became more and more dyspneic. A size two-year tube was inserted and gave complete relief. An hour later the child became dyspneic again, and laryngoscopy showed the tube blocked by mucopus. It was removed; the larynx and trachea were given a suction treatment, and after a half-hour the tube had to be put back. This was repeated in thirty-two hours. Six days later, the tube was removed on trial, but it had to be replaced within five minutes. Seven days later, it was again removed on trial, but the child became dyspneic within fifteen minutes and was re-intubated, this time with a size one-year tube. After five hours, it was coughed up and had to be replaced three hours later. An hour later, it was again coughed up, and he had to be re-intubated, a size two-year tube being inserted this time. Four days later, another trial extubation was performed, but within a few minutes he became very dyspneic and a size one-year tube was inserted. Eighteen hours later, the tube was coughed up, but the respiratory embarrassment was not severe enough to require intubation. For three days he had occasional attacks of severe dyspnea with deep retractions and restlessness. These were worse at night. However, reintubation was avoided, and the child was discharged on the forty-second day of illness. There were no complications except for a moderate degree of atelectasis in the right upper lobe. The child was seen six months later and found to be in excellent health with a strong, clear voice of normal range.

3. *Tracheotomy:* The tube is removed immediately after a tracheotomy is done.

Of the 261 cases, forty-five were treated by suction and intubation, and only four of these were tracheotomized. The four tracheotomized patients and twelve of the other forty-one patients died. The average number of intubations performed on patients who recovered was 2.9.

No child had to be intubated more than eight times. The average number of suctions in these cases was 4.5, and in only one case was suction applied more than nine times. This child, after a four-day interval of normal breathing, again developed respiratory obstruction, probably of nondiphtheritic origin. He required several more suctions and then intubations. Altogether he had sixteen suction treatments. The average number of days that a tube remained in the larynx in patients who recovered was six days. It varied from nine hours to nineteen days. The age range of patients who recovered was from six months to eight years, the average age being a little over two years.

Tracheotomy

The combined suction-intubation treatment of laryngeal diphtheria has eliminated practically entirely the need for emergency tracheotomy. There is no emergency situation which could be relieved better by a tracheotomy than by this combined treatment, except in cases with extreme cellulitis of the pharynx and neck or extreme supraglottic edema. The latter has not been seen by us and is too rare to merit consideration. If tracheotomy is performed, it is done by election, as the best course of treatment, rather than as a last resort.

Indications for Selective Tracheotomies.—1. *Repeated Block of Intubation Tube:* If this occurs, it is more often due to secretions, rather than to real membrane, although the latter may sometimes be copious enough to cause this condition. As described before, plugging of the tube causes complete obstruction and requires immediate extubation, followed by suction and usually reintubation. It entails the danger of sudden, fatal asphyxia before aid arrives or of progressive exhaustion following a succession of asphyxial attacks. The types of cases in which tracheotomy is considered are:

a. Children with very frail constitutions.

b. Patients who fail to rally quickly after one or two asphyxial attacks.

c. Patients who block up their tubes more often than every three or four hours.

Of course, these are not hard and fast rules, and every case must be dealt with as an individual problem. In our series, three diphtheritic patients had to undergo a tracheotomy because of repeated blocking of the tube. All three died. Of these, two on autopsy were found to have extensive bronchial and bronchiolar involvement and pneumonia. A fourth patient was tracheotomized because the tube gave very little relief. This child also died, and on autopsy there was extensive bronchial and bronchiolar involvement which no instrumentation

could remove. The tracheotomy gave no added relief and was really not indicated.

2. *Repeated Cough-Up of Intubation Tube:* This condition has the same general effect upon the patient as repeated blocking. It can, however, usually be remedied by the use of a larger tube. In our experience, no case of diphtheria was tracheotomized because of too frequent cough-up of tubes.

3. *Danger of Chronic Tubes:* As described before, the tube is not allowed to remain in the larynx for more than three weeks. This does away entirely with the danger of the patient becoming a chronic tube carrier. In our experience, no case of diphtheria required a tracheotomy for this reason.

Complications of Tracheotomy.—Besides the complications usually mentioned, namely, hemorrhage, pneumothorax, subcutaneous or mediastinal emphysema, and mediastinitis, we may add:

1. *Aspiration Pneumonia:* If mouth feeding is resumed too soon after an intubated child has been tracheotomized, food may be aspirated. The authors have seen two cases, both nondiphtheritic, in which liquid feedings were coughed up through the tracheotomy tube.

2. *Profuse Tracheobronchial Secretions:* These cause obstruction below the tube, requiring repeated suction through the tracheotomy tube, the tracheotomy wound, or the larynx. However, in our series, this condition occurred only in the nondiphtheritic croups and is discussed fully in that part of the paper.

COMPLICATIONS OF DIPHTHERITIC CROUP

Classification of complications

I. Due to toxins
   - A. Myocarditis—cardiac failure
   - B. Nephritis
   - C. Paralyses

II. Following closely upon local obstruction
   - A. Pneumonia
     1. Bronchial
     2. Lobar
   - B. Atelectasis
     1. Patchy
     2. Lobar
   - C. Emphysema
     1. Pulmonary
     2. Extrapulmonary
        - a. Mediastinal
        - b. Subcutaneous
        - c. Retroperitoneal
   - D. Pneumothorax
   - E. Myocardial failure

III. Due to superimposed secondary infections

A. Mediastinitis
B. Empyema
C. Septicemia
D. Otitis media

Order of Frequency

Pneumonia	45 cases	17 per cent	
Myocarditis	29 cases	11 per cent	(nontoxic—11 cases or 4 per cent)
Atelectasis	17 cases	6.5 per cent	
Otitis media	17 cases	6.5 per cent	
Septicemia	6 cases		
Empyema	4 cases		
Mediastinitis	4 cases		
Nephritis	4 cases		
Pneumothorax	2 cases		
Cellulitis	1 case		
Pyelitis	1 case		

In all, seventy-nine, or 30 per cent, of the patients suffered from complications of one kind or other.

Complications Due to Toxins

It is an old observation that diphtheria of the larynx and trachea is not associated with the toxicity or toxic sequelae of the nasopharyngeal type of the disease. Several explanations have been advanced. One is that the columnar and squamous epithelium show a difference in depth of membrane penetration and, consequently, in amount of toxin absorption. Another theory is the better lymphatic drainage and toxin absorption from the pharynx. A third theory is that the bacteria, which produce toxic and nontoxic cases, are different strains of diphtheria bacilli, the so-called mitis and gravis. The existence of combinations of the two types, that is, toxic diphtheria combined with croup, seems to invalidate this theory. At the Willard Parker Hospital, the incidence of croup was 23 per cent in toxic and 26 per cent in the nontoxic cases. However, because of their greater severity, a higher percentage of toxic cases are hospitalized, so that in reality croup is probably more frequent in toxic than nontoxic cases.

A. *Myocarditis.*—Myocarditis in diphtheritic croup occurs in two types of cases: first, in toxic cases with severe pharyngeal involvement, and second, in severely obstructed cases requiring repeated instrumentation to overcome prolonged respiratory difficulty. The former differs in no way from that in the toxic diphtheria patient without croup. There is the usual impairment of conduction and muscle function, and the condition requires no further discussion here. In the obstructive type of case, cardiac involvement is evidenced clinically during the nonobstructive periods by a rapidly climbing pulse

rate, poor pulse volume and quality, embryocardia at times, poor vasomotor tone with cold clammy extremities, cyanosis, and tachypnea. The electrocardiogram shows no more than a sinus tachycardia and a low potential. Without these symptoms, the patient may successfully weather repeated attacks of severe anoxemia even after prolonged respiratory arrest. However, when the heart is weakening under the strain, acute anoxemia is accompanied by irregularity, weakness, and sometimes by marked temporary slowing of the heart beat. These signs do not continue after the relief of the obstruction but are replaced by the rapid, weak, regular pulse as described above. Excluding eighteen cases of severely toxic diphtheria, there were in this series eleven cases which showed such symptoms of myocardial damage. The complication occurred only in severely obstructed cases, as indicated by the treatment which was required. One patient received no mechanical intervention; five were given suction; and five more required intubation. The myocarditis manifested itself at the time of the obstruction and continued after its relief. Six of the eleven patients died.

B. *Nephritis.*—We have never seen severe clinical nephritis in cases of diphtheritic croup of the nontoxic type. Moreover, in only four cases in the entire series were we able to find even urinary evidences of renal damage. In all these cases the nephritis occurred early in the illness, coincident with signs of myocarditis in three patients. Albumin, casts, and red blood cells were present in the urine. These findings cleared up shortly, and all patients recovered uneventfully.

C. *Postdiphtheritic Paralyses* in nontoxic cases have not occurred in the experience of the authors.

Complications Due to Local Obstruction

A. *Pneumonia.*—Next to mechanical obstruction and cardiac deficiency, pulmonary complications constitute one of the most important factors in the outcome of the croup case. Clinically it is difficult in most cases to determine exactly what type of pathologic change exists, but the development of pneumonia is suggested by the temperature elevation, increased respiratory rate despite relief of obstruction, scattered crepitant râles when the obstruction is not severe enough to prevent the opening of alveoli, increased cough productive of more mucus than before, greater prostration of the patient, and the roentgen-ray pictures of the chest. The latter were taken routinely on admission and repeated as indicated. Pneumonia occurred in forty-five cases, or 17 per cent. There was no definite seasonal incidence other than the general seasonal occurrence of diphtheritic croup. Comparison of the age incidence showed pneumonia to be more frequent in the earlier years.

Of patients under 1 year, 42 per cent contracted pneumonia.
Of patients from 1 to 2 years, 27 per cent contracted pneumonia.
Of patients over 2 years, 14 per cent contracted pneumonia.

As seen below, the type of case seems to be the most important factor in the frequency of pneumonia.

In Group I, 3.4 per cent of the patients contracted pneumonia.
In Group II, 15.5 per cent of the patients contracted pneumonia.
In Group III, 70.6 per cent of the patients contracted pneumonia.

It is difficult to attempt to correlate the development of pneumonia with the mechanical treatment given the patient. The statement has been made that suction or intubation may predispose to pulmonary infection. It is true that in our series there seemed to occur such a correlation.

Patients receiving no treatment, 5 per cent had pneumonia.
Patients receiving suction only, 15.5 per cent had pneumonia.
Patients receiving suction-intubation, 45 per cent had pneumonia.
Patients receiving tracheotomy, 75 per cent had pneumonia.

Deductions from these figures must be fallacious, since, of necessity, the more severely infected cases received the more advanced degree of therapy. In our experience, the pneumonia often antedated the treatment and seldom seemed to bear close chronologic relationship to such procedures. The majority of the cases showed the presence of pneumonia at the time of admission to the hospital, even though early in the disease. Often, the onset of laryngeal symptoms appeared to be coincidental with that of the pulmonary disease. Thus, 10 per cent showed pneumonia on the first day of croup; 25 per cent in the first two days; and only 10 per cent first showed pneumonia later than the fifth day of croup.

In all but four cases the pneumonia was of the bronchial type. It is worthy of note that the right lung was almost invariably involved (three exceptions in this series). The roentgen-ray shadow is patchy or confluent and usually within the limitations of a single lobe, especially the right upper lobe. This lobe was involved alone or together with other parts of the lung in twenty-nine out of forty-one cases; the right middle lobe, in nine cases. In the most severe cases, particularly in those terminating in death, the disease process extended to other portions of the lung coincidently or in successive advances. Cases which came to autopsy revealed the older and greater portion

of the pneumonia almost always in the posterior portion of the lung areas involved. The patients suffer long drawn-out illness with protracted temperature elevation. The roentgen-ray picture shows very slow retrogression, lasting from two weeks to a month or more.

The disease was lobar in four cases. An entire lobe (the right upper in all) became consolidated with all the physical signs of such consolidation and typical clinical picture and course of lobar pneumonia. Two of these four died.

B. *Atelectasis.*—It is very difficult to differentiate between pneumonia and atelectasis except when the latter is sufficiently extensive to produce gross changes in lung volume. Furthermore, it is recognized that the two processes are often coincident and that atelectasis is probably an important etiologic factor in the development of pneumonia. Nevertheless, there were certain distinguishing features which compelled the authors to explain roentgen-ray findings in seventeen cases, or 6.5 per cent, as atelectatic rather than pneumonic. The shadows were usually patchy and present along the lung periphery, especially the paramediastinal and paravertebral areas and the extreme bases. There were no associated clinical features such as occurred in the pneumonia patients to indicate that an extra burden was being added to the distress caused by the laryngeal obstruction. The temperature curve was not affected. Physical findings were in most cases absent. Only routine roentgen-ray studies disclosed the existence of pulmonary abnormality. The atelectasis was usually discovered very early in the disease, in practically every instance before the fourth day of croup. The complication is short lived, disappearing completely or in large part within one to three days.

Such patchy atelectasis may no doubt follow actual obstruction of bronchioles by membrane. But the marginal distribution of the atelectatic patches suggests that incomplete aeration due to diminished pulmonary expansion is the important factor in its pathogenesis.

Incidence of atelectasis according to the groups:

Group I:	1 in 117 cases,	or	1 per cent
Group II:	11 in 110 cases,	or	10 per cent
Group III:	5 in 34 cases,	or	15 per cent

Incidence of atelectasis in relation to treatment required:

No treatment—	2 in 100 cases		2 per cent
Suction only—	7 in 116 cases		6 per cent
Intubation—	7 in 41 cases		17 per cent
Tracheotomy—	1 in 4 cases		25 per cent

In three cases there was definite collapse of an entire lobe (R.M.L., L.L.L., L.L.L.) associated with percussion dullness, distant or absent breath sounds, mediastinal shift, and narrowing of intercostal spaces on roentgen-ray study. Such labor collapse was the direct result of bronchial occlusion by membrane, as was proved by necropsy in one case, and confirmed by response to suction in another.

C. *Emphysema.—Pulmonary:* Scattered pulmonary emphysema in conjunction with the patchy atelectasis cannot be demonstrated clinically but has been found on necropsy. If present, it, no doubt, contributes toward the inefficient aeration and diminished vital capacity.

Extrapulmonary Emphysema: The discrepancy between chest excursion and lung expansion during inspiration through the partially obstructed glottis results in tremendous pull upon the alveolar walls. The expiratory effort against the same obstruction causes a similar strain upon the alveoli. As a result, rupture of the alveoli is to be expected and does occur.[19] Air, extravasated into the cellular tissue of the lung, spreads along the bronchi and vessels to the hilus and thence into the mediastinum.[20] The soft areolar tissues of the mediastinum become infiltrated with air blebs which then pass up through the superior aperture of the thorax into the subcutaneous tissues of the neck, where crepitations can be felt. Such subcutaneous emphysema may remain localized about the neck or may spread in all directions. One case showed crepitations from the scalp down to the wrists and groins with large balloonlike air pockets in places.

Very rarely the mediastinal air may pass caudally through the aperture in the diaphragm, causing retroperitoneal emphysema with occasional invasion of the perirenal fat.[20]

Mediastinal emphysema, if sufficiently extensive, is demonstrable by roentgen-ray examination which shows vertical striations and fuzziness of the heart borders. The subcutaneous emphysema is, of course, readily recognized. Its presence always presupposes mediastinal involvement.

Extrapulmonary emphysema does not influence the prognosis directly. We have seen no case in which the air collection, either cervical or mediastinal, caused obstructive difficulty of its own. The air is readily absorbed after its continued extravasation is stopped by relief of the obstruction.

D. *Pneumothorax.*—Just as air extravasates into the cellular tissues of the lungs, so it may appear immediately subjacent to the visceral pleura. Such subpleural blebs have been seen on necropsy. Rupture of such a vesicle leads to pneumothorax which occurred in two cases. These patients were not tracheotomized, and there was no reason to suspect an artificial aeroporotomy. An interlobar collection of air occurred in one case.

Complications Due to Secondary Infections

Mediastinitis.—Associated with the mediastinal emphysema, there was found on necropsy in four cases evidence of secondary infection of the areolar tissues of the mediastinum. The tissues were soft, gelatinous, but not grossly purulent. In one case, definite suppuration did occur and was suspected during life. Despite gross pus collections, no mechanical obstruction was experienced. The infection later spread to both pleural cavities. At autopsy the patient had extensive pneumonia, bilateral empyema, and septicemia. A hemolytic streptococcus was the offending organism.

Empyema occurred in four cases following pneumonia. Three of them died.

Septicemia occurred in six cases. All died. The septicemia was associated with pneumonia in all, and also with empyema in three, with otitis media in one, and with extensive cellulitis in a marantic child. Blood cultures during life showed *Streptococcus hemolyticus* in four cases and *Streptococcus viridans* in two.

Otitis media occurred in twelve cases, or 5 per cent, of the series.

Cellulitis occurred in a marantic child who died.

Pyelitis occurred in one case associated with pneumonia. There was pyuria during life and pyelonephritis on necropsy.

Prognosis of Diphtheritic Croup

The cases in this series have been analyzed for any factors bearing possible statistical relationship to the end-results, as measured by duration of illness, incidence of complications, and mortality.

Age.—The younger patients were more prone to complications, especially pneumonia. The mortality is difficult to evaluate because of the small number of deaths, but it is interesting to note that 43 per cent of the patients under one year died as compared to 19.6 per cent of those in the second year of life and 8 per cent of those older.

Season.—The time of the year did not seem to affect the severity of the disease or the ultimate outcome.

Admission Blood Study.—White blood counts showed only that a polycytosis often presaged a longer illness than average.

Admission Temperature.—Although the temperatures were taken at different stages of the disease and under varying circumstances, the height of the fever seemed to have definite prognostic significance. Dividing the cases into two groups, those below and those above 103° F., we found 25 per cent of the former had some sort of complication as compared to 61 per cent of the latter, and 15 per cent of the former had pulmonary complications as contrasted with 42 per

cent of the latter. Mortality figures are even more striking; there is the remarkable difference between 9.7 per cent for the patients with an admission temperature under 103° F. and 45.0 per cent for those above 103° F.

Antitoxin.—All patients received antitoxin immediately after admission to the hospital. Strangely enough, the duration of the disease or of the croup before the diphtheria antitoxin was given seemed to affect the end-results, as statistically analyzed, only to a slight extent. Neither the incidence of complications nor the death rate was demonstrably lowered by earlier administration, but the duration of the entire illness was shortened. Although it is the firm belief of the authors that antitoxin is of great value and should be given as early as possible, it seems, nevertheless, to be true that its effect is not as strikingly or unquestionably manifested in laryngotracheal diphtheria as in the more common tonsillar and pharyngeal infection. This is, no doubt, due to the multiplicity of extraneous mechanical factors which modify the clinical picture and to the fact that involvement of the trachea seldom gives toxic manifestations.

Bacteriology.—The authors find it impossible to draw any prognostic conclusions from the presence of pyogenic organisms in conjunction with Klebs-Löffler bacilli.

Follow-Up.—Twenty-one of the most severe cases were seen within a year after discharge. Of these, two received aspiration once; two, three times; two, four times; and three, five times. All were in excellent health. There was a history of recurrence of croup in only two cases, and all had strong voices. The voice of one patient, who had received three aspirations, was of a somewhat lower pitch than normal, and another, who had four suctions, was slightly hoarse.

There were twelve patients who had received suction from two to sixteen times, and intubation from one to eight times, the combined treatment continuing from two to twenty-two days. All were in good health, and all had strong, clear voices, except two, who were slightly hoarse. One of these had been intubated once for a period of four days, and the other twice over a period of five days. The last patient came back to the hospital one month after discharge with a severe nonspecific infectious croup necessitating intubation for a period of three days. One other patient, who had been intubated once for a period of five days, had two mild attacks of laryngitis. In three patients, the voice was of lower pitch than normal. Two of these had been intubated once for a period of two and five days, respectively. The other had six intubations over a period of four days. In all the others the pitch was normal.

Pathology.—The location and extent of the infection and the association of toxic faucial diphtheria were the most important factors in determining the chances of life and death. Of the 117 cases of laryngeal diphtheria, three, or 2.6 per cent died; of the 110 cases of laryngotracheal infection, six, or 5.5 per cent, died; and of the thirty-four cases with involvement of the larynx, trachea, and bronchi, twenty-three, or 67.6 per cent, died.

It is noteworthy that of the twenty-five severely toxic patients with involvement of the tonsils, uvula, palate, and pharynx and greatly enlarged cervical glands, seventeen fell into Group III, three into Group II, and five into Group I.

The mortality of toxemic croups was 64 per cent contrasted with 6.8 per cent in nontoxemic croups and with 45 per cent in patients with toxemic faucial diphtheria without croup.

TABLE I

RESULTS IN DIPHTHERITIC CROUP

TYPE OF CASE		TOTAL	LARYNGITIS	LARYNGOTRACHEITIS	LARYNGOTRACHEOBRONCHITIS
Number of Cases		261	117	110	34
Primary Type		8	5	2	1
With Palliative Treatment		100	96	1	3*
With Any Type of Mechanical Treatment		161	21	109	31
Requiring Suction Alone		116 (46%)	21	80†	15
Requiring Suction and Intubation		41 (16%)	0	28	13
Requiring Suction, Intubation, and Tracheotomy		4 (1.6%)	0	1	3
Average Number of Suctions in Nonintubated Patients Who Recovered		2.1	1.4	2.0	4.2
Average Number of Suctions in Intubated Patients Who Recovered		4.3	0	4.0	8.0
Average Number of Intubations in Patients Who Recovered		2.9	0	3.0	2.0
Deaths in Cases With Palliative Treatment	Nontoxic	1 (4%)	1	0	0
	Toxic	3	1	0	2
Deaths in Cases Receiving Suction	Nontoxic	8 (10%)	1	2	5
	Toxic	4	0	1	3
Deaths in Cases Receiving Suction and Intubation	Nontoxic	6 (29%)	0	1	5
	Toxic	6	0	1	5
Deaths in Cases Tracheotomized	Nontoxic	2 (100%)	0	1	1
	Toxic	2	0	0	2
Toxemic Cases		25 (9%)	5	3	17
Deaths in Toxemic Cases		16 (64%)	1 (20%)	2 (66.7%)	13 (76%)
Total Deaths and Per Cent Mortality in Nontoxic Cases		16 (6.8%)	2 (2%)	4 (4%)	10 (59%)
Total Deaths and Per Cent Mortality in All Cases		32 (12%)	3 (3%)	6 (5.5%)	23 (68%)

*One of these patients coughed up a laryngotracheobronchial cast and recovered.

†One patient was tracheotomized in another hospital and sent to us two hours later. On admission, the tracheotomy tube was removed and the wound was closed. She required two suction treatments.

RESULTS IN DIPHTHERITIC CROUP

The maximum number of suctions in nonintubated patients was five; in intubated patients, nine, except one child who developed a secondary nondiphtheritic infection after four days of normal breathing and required further suction and then intubation. In this case there were sixteen suction treatments in all. No patient was intubated more than eight times. The number of days the tube remained in the larynx in patients who recovered ranged from nine hours to nineteen days, averaging six days. The age of intubated patients who recovered ranged from six months to eight years.

DISCUSSION OF RESULTS

This series includes twenty-five cases of toxic diphtheria. In these patients, the croup was an added feature in a disease characterized by extensive nasal, tonsillar and palatal involvement, severe diphtheritic fetor oris, cervical adenopathy, sufficient to merit the description "bull-neck," and clinical and electrocardiographic evidences of myocardial damage. The presence of toxemia introduced new problems. The indications for mechanical relief of respiratory obstruction were materially altered, and the outlook was considerably darkened. In the cases associated with toxemia, there was a mortality of 64 per cent compared to 6.8 per cent in the nontoxic cases. It is interesting to note that during this same period out of eighty-five patients treated for toxic diphtheria without laryngeal or tracheobronchial involvement, 45 per cent died. Therefore, for a better exposition of the rôle of toxemia in diphtheritic croup, the toxic and nontoxic cases have been analyzed separately in certain sections of Table I.

Of the one hundred patients who received only palliative treatment, three were in Group III. One of these coughed up a laryngotracheobronchial cast, and two were extremely toxic and moribund on admission and died shortly afterward from obvious heart failure and without signs of respiratory obstruction. Postmortem examination, however, showed membrane extending into the bronchi.

There were 116 patients, or 46 per cent, who required suction for the relief of severe respiratory obstruction. Without the use of this form of therapy, all of these would have required either intubation or tracheotomy. In this group there were twelve deaths, four of which were in toxic cases. The other eight represent a mortality of only 7 per cent. Although it is expected that this group should have a lower mortality than cases which finally had to be intubated or tracheotomized, because the latter are usually more severe, we feel that so low a death rate is encouraging for any group of diphtheritic croups with sufficient obstruction to manifest our clinical criteria for

mechanical intervention. This feeling is enhanced by the fact that 82 per cent of these patients had extension of the disease below the larynx. Our opinion, based upon clinical observations more than direct deductions from this analysis, is that avoidance of intubation or tracheotomy by means of the aspiration treatment does lower the mortality rate. Platou and Hilleboe[21] reach the same conclusion by statistical compilation. It may be interesting to note that Bradford and Leahy,[22] who did not use the aspiration treatment, had to perform intubation in thirty-one out of thirty-eight cases, with a total mortality of 31 per cent.

DISCUSSION OF DEATHS

The causes of death given below are based upon clinical findings and upon postmortem examination of 73 per cent of the thirty-two fatal cases.

There were three deaths in Group I. One was a marantic infant who developed extensive cellulitis of an arm, sepsis, bronchopneumonia, and intestinal intoxication. The second died of anaphylactic shock immediately after intravenous injection of antitoxin. The skin and conjunctival tests had been negative for horse-serum sensitivity. The third was a thirty-one-year-old negress, severely toxic and with only slight respiratory obstruction, who died a sudden cardiac death.

There were six deaths in Group II. Three of these patients had septicemia, associated with pneumonia in one; otitis, pneumonia and empyema in another; and pneumonia, empyema, and suppurative mediastinitis in the third. Two patients died of toxemia and myocarditis, one of these being complicated further by an axillary lymphosarcoma, pneumonia, and hemothorax. The sixth patient, although breathing easily through an intubation tube, died suddenly during a gavage, evidently of heart failure.

There were twenty-three deaths in Group III. Thirteen of these were toxic patients; ten of these cases were further complicated by bronchopneumonia. Of the ten nontoxic patients, three died of extensive pneumonia with an outpouring of profuse secretions into the bronchial tree. The other seven cases had complete membranous casts filling the air passages down to the smallest bronchioles, and practically all were associated with pneumonia. Tracheotomy was of no avail in four of these cases.

REFERENCES (PART I)

1. Tucker, Gabriel: South. M. J. **25:** 723, 1932.
2. Thomson, J.: Edinburgh M. J. **38:** 205, 1892.
3. Janse, H. M.: Ann. Otol. Rhin. & Laryng. **39:** 99, 1930.
4. Bagg, C.: J. A. M. A. (abstract) **94:** 69, 1930.
5. Duke, W. W.: Illinois M. J. **64:** 174, 1933.
6. Boothby, W. M.: Proc. Staff Meet. Mayo Clin. **7:** 557, 1932.
7. Korol, Ephraim: Arch. Int. Med. **51:** 264, 1933.

8. Lynah, H. L.: Laryngoscope **26:** 1193, 1916.
9. Dupuy, Homer: New Orleans M. & S. J. **76:** 113, 1923.
10. Boebinger, M. P.: New Orleans M. & S. J. **78:** 84, 1925.
11. Hart, V. K., and Peeler, C. N.: Arch. Otolaryng. **13:** 714, 1931.
12. O'Dwyer, J. P.: American Lancet **17:** 447, 1893.
13. Tolle, D. M.: Am. J. Dis. Child. **39:** 954, 1930.
14. Gover, R. W., and Hardman, R. P.: Arch. Pediat. **40:** 170, 1923.
15. Welford, N. T.: Am. J. Dis. Child. **37:** 944, 1929.
16. Hart, V. K.: Ann. Otol. Rhin. & Laryng. **39:** 636, 1930.
17. Arbuckle, M. F.: Ann. Otol. Rhin. & Laryng. **39:** 134, 1930.
18. Thomson, St. Clair: Diseases of the Nose and Throat, p. 505, New York, 1926, D. Appleton Century Co.
19. Gehrt, J.: Deutsche med. Wchnschr. **46:** 1052, 1920.
20. Jessup, P. M.: Arch. Surg. **23:** 760, 1931.
21. Platou, E. S., and Hilleboe, H.: Am. J. Dis. Child. **47:** 970, 1934.
22. Bradford, W. L., and Leahy, A. D.: Am. J. Dis. Child. **40:** 298, 1930.

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PROTECTIVE INOCULATION AGAINST TUBERCULOSIS IN INFANTS BY THE USE OF HEAT-KILLED HUMAN TUBERCLE BACILLI

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IN RECENT years many attempts have been made to induce immunity against tuberculosis in human beings. Among the later methods employed is the use of a vaccine made from killed virulent tubercle bacilli, a preparation which has given demonstrable immunity in animals, but which has been used in man by comparatively few investigators. At the suggestion of Dr. S. A. Petroff, we began in January, 1930, the injection of this vaccine in infants to determine whether it afforded them any protection against tuberculous infection. This report is merely a statement of method and a record of progress in the investigation. It is in no way an attempt to draw final conclusions regarding the value of this vaccine in the production of immunity against tuberculosis.

Adequate reviews have been written of the numerous animal experiments demonstrating the production of allergy and a certain degree of immunity to tuberculosis by the inoculation of killed tubercle bacilli.[1, 2, 3, 4, 5, 6] After Langer[7] succeeded in protecting the monkeys in the Berlin zoo from tuberculosis by inoculation with a vaccine made of heat-killed bovine bacilli, several European investigators applied his method to children. Out of forty-four children inoculated by Zadek and Meyer[8] between 1924 and 1929, and observed for periods of from one to four years, only one developed a demonstrable tuberculous lesion although they were all in homes where there was active tuberculosis. Ten of these children died of intercurrent disease. Within five months a positive tuberculin test had developed in all the inoculated subjects. These workers concluded that allergy can be produced by this method but that too few observations were made to determine the degree of protection the vaccine afforded although there seemed to be some immunity conferred.

Fedders[9] (1925) and Dold[10] (1927) both feel that while children given the Langer vaccine develop a state of allergy, they are just as liable to tuberculosis as those who have not been inoculated. We

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shall not attempt to enter the controversy of the allergy-immunity relationship in tuberculosis. The use of the Langer vaccine has been urged in this country by Gasul[11] and Brachman.[12]

METHOD

All the vaccine used in our work was supplied by Dr. S. A. Petroff, director of the Research Laboratory at Trudeau Sanatorium, and was prepared as follows:

A known strain of human tubercle bacillus, H_{37} was cultivated on synthetic fluid media of pH 7.6. The organisms were harvested at the end of three or four weeks, triturated with saline, and the suspension sterilized in a water-bath at 100° C. for one hour. The strength was determined, then diluted so that each cubic centimeter contained 0.3 mg. of bacilli. This diluted suspension was put in sterile ampules with special rubber stoppers and again sterilized at 100° for fifteen minutes. Before the preparation was released from the laboratory, the sterility was determined by guinea pig inoculation.

We limited the use of the vaccine to newborn babies or very young infants without previous exposure to tuberculosis whose tuberculin tests were negative. No infants were inoculated unless there were reasonable expectations of their being exposed to active tuberculosis. The children who received vaccine were given the same medical and social aid after discharge from the hospital as the other children in the clinic who were exposed to tuberculosis.

Intramuscular injection was the only method of inoculation employed. At first both the deltoids and gluteal muscles were used as injection sites, but because of occasional abscess formation the later patients have been given the inoculation in the buttocks only. Fifty-eight children were given four injections at weekly intervals of from 0.03 mg. to 0.1 mg. each, which corresponds to a total of from 36 to 120 million bacilli. In fifteen instances we have given a single injection of from 0.1 mg. to 0.3 mg. Whenever possible the inoculation was given in the hospital and the patient kept there until his tuberculin test became positive. This was accomplished in thirty-two of the seventy-three children. The others were either inoculated at home or sent home before there was any demonstrable allergy.

After the injections of vaccine frequent tuberculin tests were made to determine when allergy developed. In many of the hospital cases, the children were tested at weekly intervals. It was not possible to test as often the infants whose allergy developed at home. All of our tuberculin testing was done by the intradermal method, using old tuberculin supplied by the United States Bureau of Animal Husbandry. This tuberculin was used constantly in the clinic, and its

potency was known to be high. In the majority of instances 1 mg. was the testing dose. When there was a marked degree of reactivity, 0.1 or even 0.01 mg. was used. A rough attempt was made to quantitate the reactions by the size of the indurated area. To avoid the possible effect of local skin sensitivity, the tuberculin tests were done each time in different areas.

After the tuberculin test had become positive, we attempted to have the children return to the clinic at monthly intervals until they were six months old, then every three months until they were two years old, and thereafter twice a year. In case of illness they were, of course, seen oftener, and when there was an increase in the exposure to tuberculosis or the development of any signs suggesting active infection, they were brought back at frequent intervals. At each visit to the clinic, a complete physical examination was made. Every three months until they were eighteen months old, the tuberculin test was repeated and an x-ray picture of the chest taken.

In the course of this study we soon became aware of the difficulties in diagnosing tuberculous infection in infancy. Physical examination is of little assistance in recognizing slight degrees of mediastinal or parenchymal involvement. Even when there is a lesion of appreciable size in the lung tissue, the physical signs of consolidation are rarely in proportion to the amount of parenchyma affected. Fine, moist râles, slight dullness to percussion and bronchial breathing may be found in transitory nontuberculous infections which, on a single examination, might be considered as specific but which, when followed over a long period of time, are obviously not tuberculous. Except in the fatal case mentioned later no tuberculous infection was found in any of our children except that involving the mediastinal glands and nearby lung tissue.

Our greatest aid in diagnosis was the x-ray picture of the chest. The criteria used for the diagnosis of tuberculosis were: 1. Persistent peripheral consolidation with involvement of the corresponding bronchial lymph nodes. 2. Enlarged mediastinal glands and increased root infiltration in the absence of obvious sinusitis, acute bronchitis, or repeated upper respiratory infections. 3. The appearance of calcification in the lung or bronchial lymph nodes. In using such liberal criteria we have probably included in the group of infected children several whose lung changes were not due to tuberculosis.

Since the inoculation rendered the tuberculin test positive, this reaction had to be disregarded as a diagnostic aid. Many times when the skin test became distinctly more pronounced, we felt sure an active infection had been acquired. In several instances a demonstrable tuberculous infection occurred at the time of the increased skin reactivity. In other cases intimate exposure to an adult with positive

sputum preceded the flare-up of the Mantoux test. In the doubtful cases we appreciated that in being unable to use the intracutaneous tuberculin test for diagnosis, we had lost the most valuable aid in the separation of tuberculosis from nontuberculous infections.

CONTROLS

The obvious and most satisfactory method of control for the vaccination would have been to inject every alternate baby. However, it would then have been necessary to keep infants of both groups in the hospital the same length of time. This was hardly feasible—first, because we could not pretend to the parents of the uninoculated children that mere admission to the hospital would have any specific effect in the prevention of tuberculosis, and second, the expense and lack of facilities made it difficult to hospitalize more than two or three infants at the same time for this type of study. On the other hand, we could not feel confident at first that the inoculation of infants with killed tubercle bacilli was a safe procedure to be carried out in the home. One can never be certain that in such children the subsequent development of allergy is the result of the vaccination or secondary to an actual infection with live organisms. It is possible that during the development of an allergic state the child may become even more susceptible to infection than he was formerly. There is also the real danger of creating in the members of the household a false sense of security, so that the usual precautions of isolation will be disregarded. This dilemma, therefore, was before us. Should we attempt to have perfect or nearly perfect conditions for inoculation without satisfactory controls, or should we sacrifice the perfection of the inoculation procedure to the establishment of a thoroughly adequate control series? We chose the former method.

Although realizing that the two groups are not completely comparable, we have chosen as a control series for the inoculated infants, a group of one hundred and ninety-six children under two years of age who were brought to the tuberculosis clinic of the Harriet Lane Home merely because of exposure to tuberculosis. None of these children came to us because of illness. The racial and geographic distribution of these one hundred and ninety-six children was almost identical with that of the inoculated group; in fact, many families were represented in both series. The two groups were followed over the same period of time and received the same medical and social aid. It is quite obvious even to the most casual observer, however, that these two series of cases are not strictly comparable since the babies inoculated in the hospital were kept there for a period of weeks, free from any contact with tuberculosis, while the others remained in the home during that early period when the chance of infection is so great.

However, it is interesting to note the mortality from tuberculosis in these exposed infants. One hundred and twenty, or 61.2 per cent of them, became infected as evidenced by the positive Mantoux reaction. At the same time, nine, or 4.6 per cent, of these children died of tuberculosis during the average period of observation of about two years. All of these deaths occurred where the exposure had been to open tuberculosis in adults. This low death rate emphasizes the impossibility of evaluating the effect on mortality of such a prophylactic measure without the use of a large series of cases.

In Table I are summarized the results of the analysis of the control group. The morbidity statistics cannot be strictly compared with

TABLE I

UNINOCULATED INFANTS OBSERVED IN THE CLINIC BECAUSE OF EXPOSURE TO TUBERCULOSIS*

		WELL	TUBERCULIN POSITIVE	DEATHS
Exposed to active infection	106	26 24.6 per cent	80 75.4 per cent	9 8.5 per cent
Exposed to inactive infection	90	49 54.5 per cent	41 45.5 per cent	0
Total	196	75 38.3 per cent	121 61.7 per cent	9 4.6 per cent

*These statistics were kindly furnished by Dr. Miriam Brailey from the Tuberculosis Clinic of the Harriet Lane Home.

those of the inoculated series because different criteria for the diagnosis of tuberculosis were, of necessity, used.

RESULTS

Up to the present time seventy-three children have been inoculated. Twenty-five have been followed for three years, fourteen for two years, eleven for one year, and twenty-three for less than twelve months.

Complications.—In none of the seventy-three vaccinated children was there observed any immediate local or systemic reaction following the injection of the vaccine. However, between two and ten months after the inoculation there occurred in sixteen children hard, painless swellings 1 or 2 cm. in diameter, situated deep in the muscle at the injection site. These masses seldom showed signs of inflammation, and when they did it was benign and rarely extended to the regional lymph nodes. The enlargement of the regional lymph glands which occurred was never of a degree comparable with that seen in pyogenic infections. The glands were moderate in size, hard and not tender. The enlargement persisted for months.

The evolution of the nodule was slow; often it gradually receded leaving in the course of a few months only a palpable increase of fibrous tissue with a slightly depressed cutaneous scar. However, in

nine children the swellings went on to abscess formation. These lesions appeared to be typical cold abscesses, and their painlessness was striking. More than once we have seen a child sitting up playing, unconcerned and in no obvious distress with a gluteal abscess 5 cm. in diameter containing no less than 10 c.c. of pus. If left alone the abscesses broke down and drained intermittently for several months finally healing with scar formation. However, several early aspirations were followed by rapid healing and less scarring. At no time have we seen any constitutional reaction accompany these abscesses and no harm result other than a small depressed scar.

The pus aspirated from these abscesses was thick, granular, grayish yellow, and often blood stained. The majority of the cells were polymorphonuclear but large numbers of mononuclear elements were also present. Acid-fast bacilli could be easily found, but guinea pigs inoculated with large quantities of the pus did not develop tuberculosis.

It is interesting that eight of the nine children who developed these abscesses at the site of the inoculation were undergoing heavy exposure to active tuberculosis either at the time of the appearance of the lesions or shortly before. One feels sure that this is similar to the Koch phenomenon in which a tuberculous focus flares up when a superimposed infection occurs elsewhere in the body. Fedders[9] produced the same effect by reinoculation with vaccine in the preallergic phase, and various workers with B.C.G. have noted the same type of reaction. This response is an argument against reinoculation even when there is an almost complete loss of allergy.

Allergy.—The many workers who have used a vaccine made of killed tubercle bacilli agree that allergy may be produced by this means. Of the seventy-three children we inoculated only one failed to react positively to 1.0 mg. of tuberculin within three months. This child later, at the age of eighteen months, developed a positive skin test, but it could hardly be ascribed to the inoculation of vaccine. The shortest time in which allergy developed was three weeks. This happened in two instances. The great majority of children developed a positive tuberculin test in from four to eight weeks, from five to six being the mean, and thirteen weeks the longest.

Neither before nor at the time of the development of allergy was there noted fever or other systemic reaction. We observed that when the intradermal test first became positive, it reached its maximum in twenty-four rather than forty-eight hours. Often an injection of 1.0 mg. tuberculin would cause the appearance of an area of induration and redness a centimeter or more in diameter. This reaction would reach its maximum in twenty-four hours and would disappear by the end of another day. A week later, however, the typical tuberculin test could be obtained, reaching its greatest size in forty-eight hours and fading gradually over the course of several days.

Having become positive the tuberculin test remained strongly so for at least three months. This may have been due to the repeated acquisition of living organisms rather than the prolonged effect of the vaccine since most of these children were in an environment where there was tuberculous infection. Oftentimes some demonstrable lesion in the x-ray or a definite known exposure to a sputum-positive person would be followed by a distinct increase in the severity of the tuberculin reaction. In the minority of cases the test diminished in intensity after three months so that in nine cases it became negative to 0.1 mg.; in three of these it was negative to 1.0 mg. Six months was the shortest time in which the reactivity disappeared. In several cases the diminution in reactivity was preceded by intercurrent infections.

Some of the children were tested with bovine and avian as well as human tuberculin. They were found to react to all three types, but the reaction to human tuberculin was the most marked. This is interesting since the allergy was produced by a known pure human strain. Quantitative differences in the reactions were not of great significance because of the variability of old tuberculin and possible errors in administration.

Immunity.—Since only fifty of the seventy-three children inoculated have been observed for more than one year, we shall confine our discussion of morbidity and mortality to this group. It seems best to separate the patients into two divisions; first, those who received their vaccine in the hospital and remained there until allergy had developed and second, the children who were inoculated at home or those who left the hospital before the tuberculin test had become positive. A further distinction should be made between the infants who went to homes where there was open tuberculosis and those who were associated only with persons having healed lesions.

Of the thirty-two babies who remained on the hospital wards until their tuberculin test had become positive, twenty-one remained entirely free from tuberculosis; nine had x-ray changes suggestive of tuberculous infection; one had clinically demonstrable parenchymal involvement for several months, and one died.*

*O. B. was inoculated in the Harriet Lane Hospital in the routine manner and kept there until she was two months old, when her tuberculin test was positive. She returned home to be cared for by a mother with active pulmonary tuberculosis and a positive sputum. From the age of from two to ten months, she remained normal to x-ray and physical examination, and her tuberculin test waned so that at the end of this period it was negative to 0.1 mg. Her mother was sent to the sanatorium and remained six weeks during which time the child was perfectly normal, and tested negatively to 1.0 milligram of tuberculin intradermally. The mother, then in the last stages of consumption, left the sanatorium against advice and came home to care for the infant, who soon developed a cough, fever, and failed to gain weight. Within a month her tuberculin test to 0.1 mg. gave a vesicular reaction, and unmistakable signs of pulmonary tuberculosis had developed. From this time until death at twenty months her course was one of steadily advancing pulmonary and generalized tuberculosis.

The speed with which this child lost her allergy in spite of the open tuberculosis with which she was associated interested us. Although she had the same exposure before and after her allergy waned, we could not understand why she developed no signs of infection until her second period of exposure following her mother's return from the sanatorium.

In the group of eighteen infants whose allergy developed at home, there was none with enough tuberculous infection to discover on physical examination. Seven showed x-ray changes in the mediastinal glands of hilar region, and eleven remained free from tuberculosis.

A summary of the cases is given in Table II. It should be emphasized at this point that none of the children who are classified as having tuberculosis because of their roentgenographic signs showed any symptoms other than an occasional cough or an increase in the number of intercurrent respiratory infections.

TABLE II

INFANTS INOCULATED AND OBSERVED FOR MORE THAN ONE YEAR

			WELL	X-RAY TBC.	CLINICAL TBC.
Patients in which allergy developed in the hospital 32	Exposed to active infection	23	17	5	1 (died)
	Exposed to latent infection or unexposed	9	4	4	1
Patients in which allergy developed at home 18	Exposed to active infection	8	3	5	0
	Exposed to latent infection or unexposed	10	8	2	0
	Total	50	32 64 per cent	16 32 per cent	2 4 per cent 1 death 2 per cent

COMMENT

Obvious difficulties are encountered in pursuing such an investigation as the one just described. Many factors have to be dealt with which are beyond the power of the investigators to alter. We have found it impossible to establish an adequate series of controls; hence large numbers of patients and long periods of observation will be necessary before we can properly evaluate the protective power of heat-killed human tubercle bacilli against tuberculous infection.

Without the use of the tuberculin test as a diagnostic aid, the morbidity from tuberculosis in children cannot be determined with any degree of certainty. We are forced to use the mortality from tuberculosis as the only real criterion of the efficacy of the vaccine.

In the inoculated group of fifty children observed for more than one year there was one death from tuberculosis or a mortality rate of 2 per cent. The death rate from tuberculosis in children brought to the clinic because of known exposure to the disease is very low (4.6 per cent in one hundred and ninety-six cases), which figure again indicates that a large number of children must be inoculated before we can approach a statistical evalution of the method.

The tuberculin test becomes positive in from three to thirteen weeks after the intramuscular injection of heat-killed tubercle bacilli. Demonstrable allergy developed in seventy-two of the seventy-three children inoculated. When the tuberculin reaction is beginning to become positive, the maximum response to the Mantoux test is observed at the end of twenty-four hours. Some days later the typical tuberculin reaction appears.

In nine cases, or 12 per cent, sterile cold abscesses developed at the inoculation site. Lymph adenitis rarely occurred, and the abscesses all healed, leaving small depressed scars.

Our work has given us the clinical impression that the inoculated children received some degree of protection from tuberculosis. It remains for us to continue the work for some years to test the validity of this impression. We feel that the method is a hopeful one and that it is much less open to criticism than the injection of attenuated living organisms. The use of the vaccine should not be widespread until many more children are inoculated under the most careful supervision. We hope to enlarge upon this preliminary report when the work has progressed to a point where more definite conclusions can be drawn.

SUMMARY

1. Seventy-three infants were inoculated intramuscularly with heat-killed virulent human tubercle bacilli.

2. The method of injection, the development of allergy and the possible production of immunity have been discussed.

We wish to thank Dr. S. A. Petroff for his suggestions in initiating the work and for the vaccine with which he so kindly kept us supplied. And we are especially grateful to Miss Georgie Walker and Mrs. E. B. Janeway, the Social Workers in the Harriet Lane Tuberculosis Clinic, whose untiring assistance enabled us to keep in touch with our patients, and whose intelligent cooperation supplied many details of home conditions and exposure to infection we would otherwise have not known.

REFERENCES

1. Soper, W. B.; Alpert, L. K.; and Adams, M. J.: Am. Rev. Tuberc. **10**: 667, 1933.
2. Petroff, S. A.: Am. Rev. Tuberc. **7**: 412, 1923.
3. Zinsser, H., and Petroff, S. A.: J. Immunol. **9**: 85, 1924.
4. Zinsser, H.; Ward, H. K.; and Jennings, F. B., Jr.: Ibid. **10**: 719, 1925.
5. Petroff, S. A., and Stewart, F. W.: Ibid. **12**: 97, 1926.
6. Petroff, S. A.; Branch, A.; and Jennings, F. B., Jr.: Ibid. **16**: 233, 1929.
7. Langer, H.: Klin. Wchnschr. **43**: 1944, 1924.
8. Zadek, I., and Meyer, M.: Deutsche med. Wchnschr. **55**: 1630, 1929.
9. Fedders, F.: Ibid. **51**: 1659, 1925.
10. Dold, H.: Ibid. **53**: 12, 1927.
11. Gasul, B. M.: Arch. Pediat. **46**: 459, 1929.
12. Brachman, D. S.: Am. Rev. Tuberc. **22**: 226, 1930.

CONGENITAL ICHTHYOSIS

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As far as can be found, the first observation of congenital ichthyosis was reported by Seeligmann in his inaugural dissertation, in 1841. This is cited by Ballantyne[1] in his book on the diseases of the fetus, in which he gives a summary of the cases found in the literature from that date to 1894. All these cases appeared to be cases of congenital ichthyosis without other pathologic changes, except the cases reported by Gould and Fermin. Gould reported two cases in which the patients suffered from umbilical hemorrhage and jaundice. Fermin found that a congestion of the internal organs occurred quite frequently, analogous to that found in cases of widespread burns, and mentioned that Church found in one case an anomaly of the aorta.

However, the very earliest mention of fetal ichthyosis is reported in 1932 by Waring[2] as being found in a diary written in colonial days by a minister named Oliver Hart, A.M., Charleston, S. C. The entry in this diary read as follows: "On Thursday, April ye 5, 1750, I went to see a most deplorable object of a child, born the night before of one Mary Evans in 'Chas' town. It was surprising to all who beheld it, and I scarcely know how to describe it. The skin was dry and hard and seemed to be cracked in many places, somewhat resembling the scales of a fish. The mouth was large and round and wide open. It had no external nose, but two holes where the nose should have been. The eyes appeared to be lumps of coagulated blood, turned out, about the bigness of a plumb ghastly to behold. It had no external ears, but holes where the ears should be. The hands and feet appeared to be swoln, were crumpt up and felt quite hard. The back part of the head was much open. It made a strange kind of noise, very low, which I cannot describe. It lived about eight and forty hours and was alive when I saw it."

In 1900, Reicke[3] reported two cases, both in female fetuses, and in his lengthy article refers to cases observed by Winfield, Gertensberg, and Wassmuth. Winfield's case showed an absence of the thyroid gland. Gertensberg thinking there might be a question of trophic neurosis made a careful investigation of the nervous system and found hemorrhage into the ventricles of the brain and into the dural space of the spinal cord. This he thought was due to injury at birth. There was also present an

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interstitial neuritis of the brachial plexus. Wassmuth found in his case atelectasis of the lungs and congestion of all internal organs, but no changes in nervous system.

In the same article Reicke discusses various comparisons of the skin which had been pointed out by other authors. For instance, Hebra compared the skin to that of a baked apple or a baked suckling pig. Houee likened it to boiled potatoes. Souty thought it simulated Morocco leather; Muller and Kollecker, a coat of mail; and Jahn compared it to the bark of a tree. Very little can be found in the literature from 1900 to 1908, when Coston[4] reported the case of an infant born about the sixth month. The placenta in this case was enormous and the amnion was three or four times as thick as normal. On the amnion and umbilical cord many ichthyotic patches were found. The parents showed no signs of ichthyosis, and no member on either side had shown any symptoms; consequently Coston did not believe in the theory of heredity as an etiologic factor. He cited that Mracek and Kerr think it is always hereditary while Edgar suggests that there is a family predisposition to the disease. Coston found that Shoemaker considers that the parents are devoid of any constitutional taint, and he found that Taylor believes there is no indication of a systemic morbid state in either parent.

In 1909, Wymer[5] reported a case in a baby who lived twenty days. Schwartz,[6] in the same year, reported a series of cases in the same family. The mother and three of her children suffered from ichthyosis. The children died at the twelfth, second, and fourth day respectively.

In 1915, Goffe[7] reported four cases in a family of six children. He said the dry scaly condition of the skin began to show itself about two months after birth in each of the children. One of the mother's brothers had suffered from a scaly skin.

Hess and Schultz,[8] in 1921, published a report of a case under the name of keratosis diffusa fetalis (ichthyosis congenita). In their paper they gave the postmortem report as well as pictures of sections of the skin and photographs of the infant.

In 1926, Kingery[9] reported a case of ichthyosis congenita in an infant who also showed an unusual complication. The index finger and thumb became discolored and cold to the touch and then became gangrenous just before death at the age of six weeks. The infant's entire body at birth was encased in an extremely light, perfectly fitting covering, which looked like heavy waxed paper. Kingery refers to Bowen who called attention to the possible abnormal persistence of a fetal membrane in these cases. In certain lower animals, a distinct outer membrane (layer) covering the hair development of the animal is present. This is given the name of epitrichium. In man this is represented by an upper layer of cells called the epitrichial layer. Kingery suggests the possibility of this membrane as a partial explanation of the foregoing picture. In the

same year, Richter[10] reported a case found in addition to the hypertrophy of the stratum granulosum, an acanthosis and sclerosis of the cutis and subcutis.

In 1929, Gaffier[11] reported his case, the third child of a woman of twenty years. Immediately after birth, the typical picture of ichthyosis was noticed. Burrows,[12] in 1932, reported a case in a man, aged fifty-six years, who had suffered from a dry, scaly skin all his life. He had two daughters, both of whom suffered from thick skins. In the same year, Ravaut and Maisler[13] reported a case in a girl, twenty years old, and Lapiere[14] reported two cases, one in a girl of twenty-one, which he described as the bulbous type, and the second case in a boy of nineteen years, which he described as the dry form. In his paper he gave a classification of the various types of the disease and suggested trying thyroid extract in the treatment of it, as so many cases showed hypothyroidism. In September of 1932, Hewitson[15] reported a case of harlequin fetus; she states that the infant was born with the disease in full evolution, the child dying on the seventh day. The mother was Chinese.

CASE REPORT

Patient was the fourth and last child in the family. The father and mother were both well and healthy. The three elder children, aged ten, seven, and four years respectively, were well and healthy. Between the first and second child, the mother had a miscarriage. There was no history of tuberculosis. One maternal aunt had a child who was born deaf. There were no other congenital abnormalities or any history of any other member of the family suffering from any skin condition as far as the parents of the patient knew.

Past History.—The baby was born apparently at full term. Labor was normal. At birth the baby was noticed to have snuffles, and the mother stated that the baby's skin looked very tight and shiny and was of a dark color. Next day, the mother said the baby appeared to be wrapped in a "dirty yellow paper" all over the body, and the skin seemed to have no pores anywhere. This condition continued from two to three weeks when the child began to grow and the skin cracked and in places peeled off. This condition covered the entire body including the hands and feet and head.

Physical Examination.—The patient when first seen at the age of six weeks, was certainly hideous to behold. The skin all over the body, including the head, arms, and legs, was cracked, and there were deep fissures which separated the skin into plaques of various sizes. All over the surface of the body there were numerous scales. The child was snuffling loudly as the nares were filled up with scales from the surrounding skin. The eyelids showed slight ectropion. There were deep fissures round the mouth, and the lips showed slight eclabium. At this time the head showed little hair. The scales and cracks were smaller about the neck and face and around the ears. The ears were filled with a scaly débris. The skin was smooth and practically normal over the whole diaper area. Chiefly because of the presence of snuffles, a tentative diagnosis of syphilis, was made, but the blood examination of the mother, father, and baby gave a negative Wassermann. At four months, when the first picture was taken (Fig. 1), blood Wassermanns were again made with negative results. At thirteen months, when the

Fig. 1.—The smooth skin over the diaper area is shown here in a photograph made when the baby was four months old.

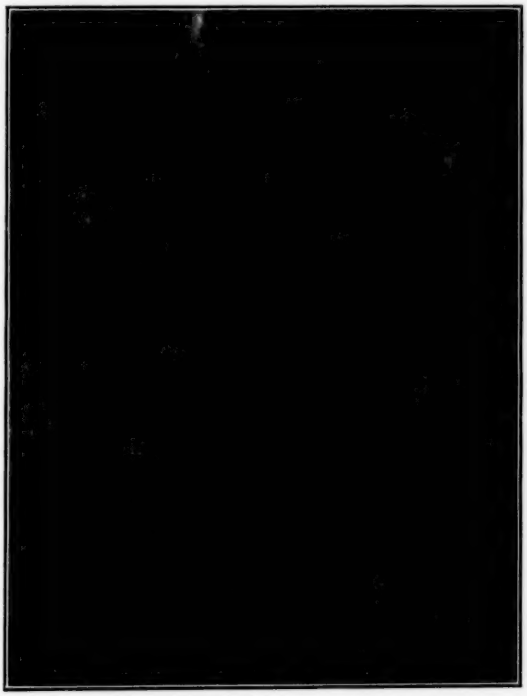

Fig. 2.—Nine months later, the area around the buttocks has become involved, since diapers are no longer used. Note the smooth skin around mouth and cheeks.

second photograph was made (Fig. 2), the skin was in about the same condition except that the skin over the buttocks now showed roughness and fine scales instead of the smooth, apparently normal appearance exhibited at first. The area around the mouth, which at that time had shown fissures and many scales, had now become nearly normal in appearance. The baby began dribbling at about four months and was still doing so at thirteen months, so that all this time its

mouth and chin were constantly wet with saliva. When the baby's diaper was wet almost continually in its infancy, the skin over this area was perfectly smooth and showed no scaling. It would look as if keeping the skin wet improves it, and relieves the condition at least temporarily. About this time, a small elliptical incision was made about 1½ cm. long and 3 cm. wide in the lower right iliac region of the abdomen, and a piece of skin and superficial fat were removed for diagnostic purposes. The pathologist's report was as follows: (1) Hyperkeratosis throughout entire section, (2) occasional small area of parakeratosis, (3) numerous holes, round and oval, containing masses of fat as well as fragmented split embryonal hairs, (4) hypertrophic horny layer resting directly on layer of keratophyalin, (5) no stratum lucidum, (6) rete layers showing slight degree of acanthosis and in the areas taped by parakeratosis the individual rete cells showing moderate degree of intracellular edema, (7) numerous mitotic areas visible, (8)

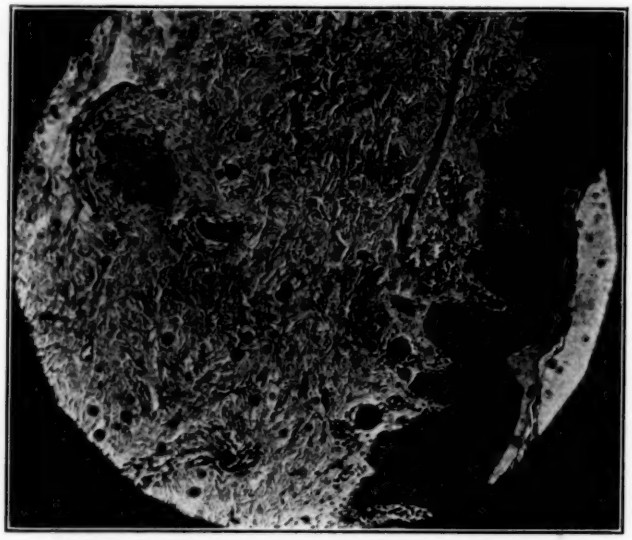

Fig. 3.—Photomicrograph of biopsy section of skin.

normal number of sweat glands, but slightly dilated, (9) only one sebaceous gland in section, (10) hair follicle shows fatty degeneration, (11) no evidence of spongiosis, (12) lymphatic infiltration beneath basal cell layer. Diagnosis: Ichthyosis universalis congenita. (See Fig. 3.)

Kehrer,[16] in 1928, made microscopic preparations of the skin of a patient of his who died a few days after birth. His report was as follows: A marked hyperkeratosis, but the lowest layer of the horny cells was not connected with the stratum granulosum. The aggregation of the single anuclear horny cells was very intimate so that the entire markedly cornified upper cutis could be detached as a single coat. The elastic fibers and the sebaceous glands and the sweat glands were decreased. Reicke's enclave bodies were present in the hornified layers. There were

concentrically stratified horny lamellae. All these findings confirmed the diagnosis of congenital ichthyosis. Kehrer's case was of the grave type, and the one reported is of the milder type.

Urinalyses and blood counts made from time to time showed nothing abnormal.

Ballantyne divides congenital ichthyosis into (1) the grave type which almost invariably proves fatal within a few days after birth, (2) the less marked variety, the so-called attenuated form, which may be quite compatible with extrauterine life, and which forms the connecting link between the first variety and the ichthyosis simplex of the adult, (3) ichthyosis hystrix, traces of which are often visible at birth, (4) the nerve nevus or neuropathic papilloma, and (5) keratosis pilaris. Gaffier divides ichthyosis congenita into three groups: (1) ichthyosis congenita gravis, (2) ichthyosis congenita larvata, (3) ichthyosis congenita tarda.

ETIOLOGY

Little can be safely stated regarding the etiology of this form of ichthyosis. That consanguinity of parents has any etiologic significance is doubtful. A possible paternal influence has been suggested. Maternal impressions or sex seem to play no part in its etiology. All that can be said with safety is that heredity is the most powerful etiologic factor, and it is of a peculiar kind known as "family prevalence." Kehrer[16] states that the lack of amniotic fluid is of great importance in the cause of the disease. It has been observed in every case, he states. As there appear in the literature so many more cases reported by Italian authors than by writers of other nationalities, one wonders if there can be a racial cause of the disease.

PROGNOSIS

The attenuated form of fetal ichthyosis has not a grave significance as regards life. There is not much hope of complete cure. Some of the cases may remain in statu quo. Some may show slight improvement, and some may increase in severity as time goes on.

The treatment adopted has been both internal and external. The chief indications are to keep up the strength of the child by proper feeding and hygiene. Externally the skin should be kept well oiled, for this is not only helpful in removing the scales, but also it tends to prevent them from reforming. In the foregoing case, cod liver oil was administered daily, and iron in the form of saccharated carbonate of iron was given for two or three weeks at varying intervals. Thyroid extract was given for one year without benefit. Externally, the child received daily oil baths.

COMMENT

1. Because of the rarity of this disease, this case is reported.

2. The case is of special interest as it should be classified between the grave type of the disease and the attenuated form. The skin appeared to be severely affected at birth, and yet the child thrived.

3. The maintenance of the skin in a moist state, as occurred during the period when the baby's diaper was frequently wet, appears to have a beneficial effect on the skin condition. Otherwise, there seems to be no reliable treatment for this condition.

REFERENCES

1. Ballantyne: The Diseases of the Fetus, Vol. II, Edinburgh, 1892-1895, Oliver and Boyd.
2. Waring, J. I.: Am. J. Dis. Child. **43:** 442, 1932.
3. Reicke, E.: Arch. f. Dermat. u. Syph. **54:** 289, 1900.
4. Coston, H. R.: Am. J. Obst. **58:** 650, 1908.
5. Wymer, J. J.: New Orleans M. and S. J. **61:** 348, 1908-1909.
6. Schwartz, H. J.: Bull. Lying-In Hosp., New York **6:** 172, 1909-1910.
7. Goffe, E. C. L.: Brit. J. Child. Dis. **12:** 143, 1915.
8. Hess, J. H., and Schultz, O. T.: Am. J. Dis. Child. **21:** 357, 1921.
9. Kingery, L. B.: Arch. Dermat. and Syph. **13:** 90, 1926.
10. Richter, N.: Arch. f. Dermat. u. Syph. **152:** 239, 1928.
11. Gaffier, Paul: Zentralbl. f. Gynäk. **33:** 1757, 1929.
12. Burrows, A.: Proc. Roy. Med. Soc. **25:** 920, 1932.
13. Ravaut, P., and Maisler, H.: Bull. Soc. franç. de dermat. et syph. **39:** 681, 1932.
14. Lapiere, S.: Ann. de dermat. et syph. **3:** 401, 1932.
15. Hewitson, M.: Malay M. J. **7:** 93, 1932.
16. Kehrer, R.: Klin. Wchnschr. **6:** 283, 1928.

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CONGENITAL CYST OF THE LARYNX

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CONGENITAL cyst of the larynx is infrequent and is rarely mentioned in the texts of pediatrics or otolaryngology. Cysts of the larynx which are considered in the texts are those which have been recognized in adult life and are chiefly retention cysts, due to the sealing over of ducts of mucous glands secondary to cicatrization of the larynx following some inflammatory process. The etiology of congenital laryngeal cysts has not been definitely determined. The following case is of interest in that the clinical picture resembled that of an enlarged thymus.

Solomon[1] reported a case of epiglottic cyst in an infant, twenty-eight days old, with a fatal outcome. Porak[1] discovered a cyst of the aryepiglottic fold in an infant at autopsy. Greene[2] reported three cases of cysts of the epiglottis discovered at autopsy. Rosenberger[3] saw a case of congenital cyst of the ventricle in a one-month-old baby who died shortly after entering the hospital. Two cases have been reported, however, which have been successfully treated by surgery. One of these cases was reported by W. B. Chamberlain[4] in which simple incision of the cyst effected a cure. The second successful result was obtained by Lorie and Lux[1] in which simple incision was followed by refilling of the cyst in nine days. Removal of the mucous membrane of the upper half of the larynx and resection of half of the epiglottis on the cyst side of the larynx were necessary to produce a cure.

The cardinal symptoms of the reported cases have been stridor, weak cry and dyspnea from birth, regurgitation of food, and poor nursing ability. The signs have been those of malnutrition, obstructive breathing, cyanosis, and deformity of the chest.

CASE REPORT

The patient, J. C., was admitted at the age of two months with the complaint since birth, of difficult breathing and cyanosis on crying.

The family history is irrelevant. The child was a full-term infant, delivered normally, weighing 8 pounds at birth. Difficult breathing and inspiratory stridor were present at birth. The cry was weak and produced marked cyanosis. X-ray treatment for enlargement of the thymus produced no improvement. The child was breast fed five weeks. Because it regurgitated its food and failed to gain, it was placed on a whole milk formula and still failed to gain. Cod liver oil and orange juice were administered in adequate amounts from the age of two weeks.

From the Pediatric Division, St. Vincent's Hospital, New York City.

Physical examination revealed a marasmic infant, weighing 6½ pounds, with moderate cyanosis and dyspnea, labored breathing, and an inspiratory grunt. There was marked retraction of the suprasternal notch, the interspaces, and both costal margins, especially on the right. The floating ribs of the right costal margin were bent medially, causing a permanent depression of the right lower chest anteriorly, accentuated by inspiration. Squeaking râles were heard throughout both lungs without change in breath sounds. Percussion note was impaired over the left chest anteriorly. Heart sounds were normal, and the heart was not shifted. The liver was slightly palpable below the right costal margin in the midclavicular line. The spleen was not palpable. Temperature was 98.6° F.; respiration, 45; and pulse, 150.

Fluoroscopic examinations of the chest showed wide excursions of both diaphragms with a seesaw motion: i.e., the right diaphragm rose while the left diaphragm descended.

Chest x-ray pictures showed a moderate retraction of the heart to the left side. A dense area that was believed to be an atelectatic area was noted at the base of the left lung. No evidence of eventration or evisceration through the left diaphragm was noted. X-ray pictures of the cervical region did not reveal any evidence of displacement or compression of the trachea.

Laboratory Data.—Schick, Mantoux, and Kahn reactions were negative.

Blood Count: Hemoglobin, 95 per cent (Sahli); R.B.C. 4,900,000, W.B.C. 14,750; polymorphonuclears, 92 per cent.

Blood Chemistry: (On admission) serum CO_2 combining power, 72 volumes per cent; chlorides, 539.0 mg. per 100 c.c.; N.P.N., 22.6 mg. per 100 c.c.; sugar, 85.0 mg. per 100 c.c.

(One hour after infusion of 200 c.c. of normal saline)
Serum CO_2 combining power, 58 volumes per cent;
chlorides, 550.

(Forty-eight hours after tracheotomy)
Serum CO_2 combining power, 45 volumes per cent.

On admission the blood chemistry revealed an alkalosis due to hyperventilation. An infusion of 200 c.c. of normal saline was given which promptly restored the plasma bicarbonate to the upper limits of normal. This produced no marked change in the condition of the patient. Three days after admission a direct laryngoscopy was performed to determine the cause of the obstruction. It was found that the left side of the larynx was filled with a reddened mass protruding toward the right and causing almost complete obstruction. The child became so cyanotic during the laryngoscopy and its condition so poor that a low median tracheotomy was performed after the bronchoscope had been introduced into the trachea to maintain an open airway. The child's condition improved at once. Cyanosis disappeared and dyspnea ceased. Repeated suction and cleaning of the tracheotomy tube was necessary to maintain a clear airway. The child took its formula well and breathed without difficulty. Râles were heard daily throughout both lungs, and although the child appeared more at ease and was more vigorous, it failed to gain weight. Six days after admission the temperature rose to 101° F. and ranged from 101° F. to 103° F. until death eighteen days after admission. Three days before death, respirations again became labored, even with a clear airway, and signs of widespread bronchopneumonia were evident.

AUTOPSY REPORT

(Dr. Alexander Fraser)

Anatomic diagnosis.—Congenital cyst of the larynx; bilateral terminal pneumonia.

Report.—The body was that of a white female child, eleven weeks old, very much emaciated. A tracheotomy wound was present in the trachea. The tracheotomy site was free from infection. The subhyoid bursa was ruptured, and a slightly milky, thin fluid was exuding from it and distributed in the neighboring area. On looking into the glottis, one could see the aperture was blocked by a cyst which by the pressure of the forceps on its laryngeal surface could be moved to the left.

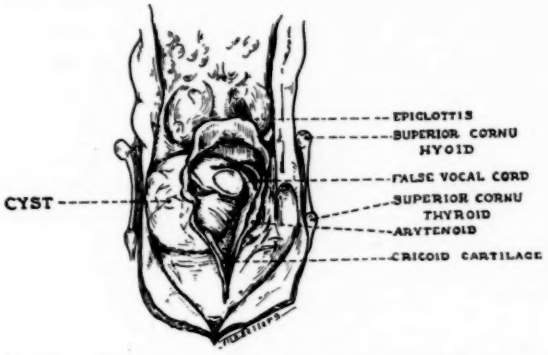

Fig. 1.—Semidiagrammatic—showing relation of cyst to external and internal structures of larynx.

Fig. 2.—Photographs of cyst in situ after injection of gelatin and hardening in formalin.

The vocal cords were exposed clearly on the right. On the left, only the false cord could be seen, and this was thinned and bulged over a cyst protruding into the left ventricle. Pressure on this cyst from the inside caused it to bulge into the left pyriform fossa. The cyst was thin walled and filled with a thin mucoid fluid.

Both lungs showed a hemorrhagic consolidation in the posterior portions of the upper lobes and throughout the bases of both lower lobes. The heart showed no abnormalities in its valves or chambers.

Microscopic Report.—Sections of the cyst wall show that it is lined with a somewhat flattened, pseudostratified, columnar, ciliated epithelium, characteristic of the epithelium normally found in this region of the larynx.

Sections of the lungs are characteristic of bronchopneumonia.

COMMENT

Patients in two of the reported cases and our case had been given x-ray radiation on the assumption that the symptoms were related to an enlarged thymus. Since four of the reported cases were diagnosed at autopsy, the question arises as to how many cases of congenital cyst have been mistakenly diagnosed as enlarged thymus, cardiac, or respiratory disease.

REFERENCES

1. Lorie, A. J., and Lux, P.: Laryngoscope **42**: 957, 1932.
2. Greene, D. C.: Laryngoscope **17**: 800, 1907.
3. Rosenberger, H. C.: Laryngoscope **37**: 360, 1927.
4. Chamberlain, W. B.: Laryngoscope **27**: 622, 1917.

INSULIN—ITS USE IN NONDIABETIC CHILDREN

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MALNUTRITION in children is a very common disorder. For the past five years we have been greatly interested in this problem and have had ample opportunity to study this phase of pediatrics through the medium of the children's department of St. Luke's Convalescent Hospital. This hospital, a new development, is situated in the country about twenty-five miles north of New York City. Here there are facilities for caring for forty-five semiacute, chronic, or convalescent children. This care considers their mental and emotional well-being, as well as their physical. It is worthy of note that the children are unusually happy and often show disappointment at the time of discharge. This can be attributed largely to their surroundings, the excellent food, and last but not least, the presence of a full-time recreational director and teacher who is extremely clever at holding the children's interest. The children are allowed up if they are well enough, and it is only with these ambulatory malnutrition cases that we are concerned in this article.

These children are up for ten hours out of the twenty-four, and outdoors for four hours. Every minute of their time up is spent in directed activities. They eat in a pleasantly furnished dining room and are fed only three times a day. No extra food is offered between meals with the exception of orange juice once a day. Each child receives one tablespoon of maltine and cod liver oil after each meal, sun baths each day during the summer months and cold quartz ultraviolet irradiation three times a week during the winter months. The food is served directly to the child's plate in the dining room from an electrically heated food truck. The diet is well rounded and balanced by a trained dietitian and offers 2,000 calories daily if only one helping is eaten. The children are allowed as many helpings as they desire, but they are never forced to eat. We have often seen children consume 5,000 calories daily without urging.

The children are drawn from either the acute pediatric wards or the pediatric clinics of the parent hospital. Some are convalescent from acute illnesses, and others are sent because of prolonged malnutrition in spite of careful clinical care and supervision. It is with this latter group that we are mainly concerned at present.

From the Pediatric Service of St. Luke's Hospital, New York.

All the children do very well from the standpoint of weight gain, but we have found that some classes of cases progress much more rapidly than others. The average rate of gain for the whole group of 643 children, whose average age is seven years, amounts to 1.4 ounces a day. This rate appears to be somewhat faster than that obtained in most of the children's institutions with which our social service has contact, and we have been satisfied with our results as a whole.

Our interest in the use of insulin in cases of underweight was stimulated by our inability to make certain children gain as rapidly as others. We tried several different methods such as added rest, between-meal feeding, and special diets, without any marked success.

Our experiment was restricted to children, most of whom were definitely underweight, who showed no evidence of acute, active disease. During the past year we have given insulin to forty-one children over varying periods. Five units of insulin were given subcutaneously twenty minutes before each meal. We experimented as to the time of injection before eating and found twenty minutes to be the optimum. We experienced no difficulty in persuading the children to come voluntarily for the injection, and in no case did we observe any untoward local reaction. The children received the insulin over an average period of about three weeks.

Upon analyzing the results at the end of the year, we find that the cases automatically arrange themselves into four main groups which will be described separately.

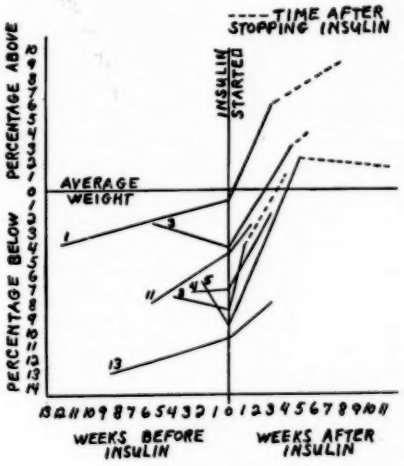
The first group consists of twelve children who were under observation for an average period of one month before insulin therapy was started. During this month their average daily gain was 0.63 ounces, or less than one-half that of the average for the whole institution over a five-year period. It was this type of child that caused us the greatest concern, as it required a much longer period of institutionalization to correct the malnutrition and also served to lower considerably the end-results as to average gain for the whole group.

Graph 1 is an attempt to show the effect of insulin upon the weight curves of the children in this group. We have drawn only a few representative lines in order to avoid confusion by the crossing and recrossing of individual lines. Each point represents the percentage of underweight rather than the pounds under the theoretical normal average; thereby discounting any differences due to variations in age and total body weight.

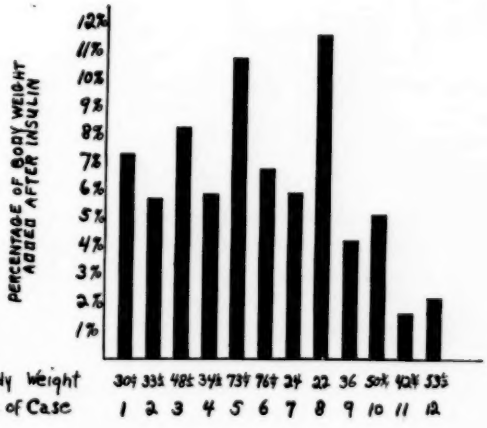
By studying the graph it can be readily seen that each line of weight gain angulates sharply at the point when insulin therapy was started. Reducing the group's figures to averages we find that these cases gained at the rate of 2.2 ounces daily after receiving insulin therapy; or three

and one-half times their former rate. In other words, we are able practically to eradicate the group of slow gainers by the use of insulin.

Graph 2 shows the actual weight of each child in this group and also



Graph 1.



Graph 2.

demonstrates the percentage of total body weight which was gained after the use of insulin therapy.

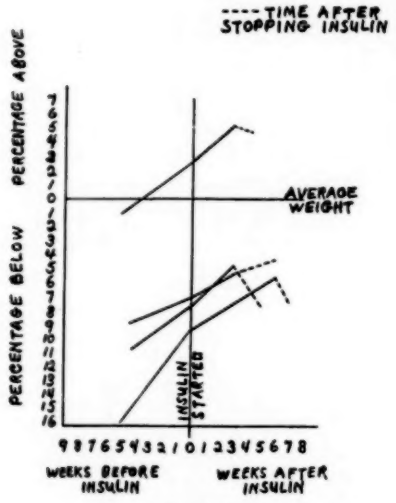
The second group consists of ten patients who, during a preliminary period of observation of about one month, showed a satisfactory rate of

gain of 1.3 ounces daily; this rate corresponds very closely to the normal average for the institution as a whole.

Graph 3 pictures a few representative cases from this group. The lines again indicate percentages of underweight.

It can be seen at a glance that the effect of insulin therapy upon this group was of very little moment. Presumably these children were already gaining at a maximum rate of speed and could not be influenced.

The third group consists of ten patients who were given insulin from the day of admission in an effort to determine whether or not the length of hospitalization could be materially shortened. An analysis of this group as a whole showed very little improvement over a control group


TIME AFTER STOPPING INSULIN
PERCENTAGE ABOVE
PERCENTAGE BELOW
AVERAGE WEIGHT
INSULIN STARTED
9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8
WEEKS BEFORE INSULIN
WEEKS AFTER INSULIN

Graph 3.

of twenty-six cases of malnutrition; this group had gained satisfactorily without the use of insulin. The comparison may be shown as follows:

	CONTROLS	PATIENTS RECEIVING INSULIN
Average Age	8 yr.	7 yr.
Average Stay	52 days	56 days
Average Daily Gain	1.03 oz.	1.4 oz.

It will be noted that the insulin group did slightly better than the controls, but that the figure for the average daily gain is practically identical with that shown by the children in Group 2, who were gaining rapidly before insulin was given. In other words, the use of insulin probably speeded up the rate of gain of any of these ten children who might have been laggards and thereby produced a normal average for the whole group.

The fourth group consists of nine patients who reacted so individually as to merit separate mention.

Two girls, ten and thirteen years old, entered the hospital markedly underweight because of poor home environment. These girls proceeded to gain weight at the rate of 1 pound a week. After several weeks of this gain insulin therapy was started in order to determine its effect upon a rapidly rising weight curve. It failed to cause any modification of the curve.

A child, three and one-half years old, who weighed only 26 pounds, had gained only ¾ pound in fifteen weeks. She was given insulin in various doses up to 8 units before each meal. In spite of definite symptoms of hypoglycemia, this child refused to eat, and insulin therapy had to be discontinued to prevent the onset of shock. She had been institutionalized for a long time due to an unsuccessful attempt to reduce a congenital dislocation of the hip. Her lack of appetite had an emotional basis, as was proved by the fact that immediately after discharging her to her home, her appetite returned, and she started to gain rapidly.

A girl, aged sixteen years, was losing weight at the rate of ¾ pound a week. She also ran an afternoon temperature and felt ill although no cause could be found by physical or x-ray examination. She was given insulin up to 15 units t.i.d. and promptly began to eat well, gaining weight back to her former level in spite of a continuance of her fever and symptoms.

A girl, four years old, weighing only 24 pounds, had been under our observation off and on since birth because of chronic inability to gain weight. Insulin therapy produced a rate of gain which exceeded any of her previous records. The dosage of insulin was stepped up gradually in an effort to determine tolerance. We finally reached the total of 17 units t.i.d. without any untoward effects. The insulin was then discontinued for a period of three weeks, because of a grip infection. It was started again with 10 units t.i.d. and the child promptly developed an acute protein anaphylaxis necessitating a cessation of treatment.

A condition of chronic diarrhea in a three-month-old baby improved immediately after starting the insulin therapy.

A girl, five years old, had failed to show any response to the usual dosage of 5 units t.i.d. She gained 2¾ pounds in two weeks when the dosage was increased to 9 units t.i.d.

A patient with a strongly positive Mantoux reaction was gaining slowly but steadily before insulin was started. Immediately after starting insulin therapy the weight curve started downhill and the child lost 1½ pounds in the next two weeks. This is the only case we had in which the use of insulin apparently had a deleterious effect upon the weight curve.

A baby, three months old, who had not gained weight for three weeks, was given insulin, 2 units t.i.d. for two days. He then developed an insulin shock which caused us to discontinue the treatment. Immediately following this the weight curve began to rise sharply without any change in the food offered, and the baby gained two pounds, or 21 per cent of his total body weight, in the next three weeks.

The question has been asked whether or not these children who receive insulin will maintain any weight gain they may show. It will be noted on the graphs that some children show a slight loss of weight immediately after discontinuing the insulin. Through the social service department we were able to obtain follow-up weights upon 45 per cent

TABLE I

GROUP	CASE	TIME WITHOUT INSULIN (DAYS)	WEIGHT CHANGE WITHOUT INSULIN (POUNDS)	AVERAGE DAILY WEIGHT CHANGE (OUNCES)	TIME ON INSULIN (DAYS)	WEIGHT CHANGE ON INSULIN (POUNDS)	AVERAGE DAILY WEIGHT CHANGE (OUNCES)	STAY AFTER STOPPING INSULIN (DAYS)	WEIGHT CHANGE AFTER STOPPING INSULIN (POUNDS)	TIME OF OBSERVATION AFTER DISCHARGE (DAYS)	WEIGHT CHANGE AFTER DISCHAEGE (POUNDS)
1	1	86	+1.0	+0.2	21	+1.2	+0.9	35	+1.0	0	–
1	2	20	+0.2	+0.16	8	+1.7	+3.4	0	–	90	0
1	3	38	−1.0	−0.4	32	+3.2	+1.6	8	+0.7	60	+1.5
1	4	17	0	0	21	+2.0	+1.5	0	–	0	–
1	5	15	−1.2	−1.2	34	+8.2	+3.8	41	−0.5	0	–
1	6	15	+1.7	+1.8	21	+5.2	+4.0	7	−1.2	0	–
1	7	26	+0.3	+0.2	32	+1.4	+1.0	21	0	90	+0.25
1	8	26	−0.2	−0.3	8	+1.0	+2.0	22	+1.2	0	–
1	9	25	+1.0	+0.6	14	+1.0	+1.1	9	+0.5	0	–
1	10	29	+2.2	+1.2	21	+3.2	+2.4	0	–	0	–
1	11	29	+1.7	+0.9	9	+1.0	+1.5	0	–	30	0
1	12	60	+1.5	+0.7	20	+1.2	+1.1	0	–	30	0
2	13	26	+3.7	+2.2	27	+1.5	+0.9	0	–	90	+2.2
2	14	32	+2.2	+1.1	21	+1.7	+1.3	10	−0.5	–	–
2	15	32	+1.2	+0.6	21	+1.5	+0.9	9	−1.0	90	+2.2
2	16	29	+0.7	+0.4	21	+1.0	+0.8	15	+0.7	–	–
2	17	29	+2.7	+1.5	28	+1.5	+0.9	35	−0.7	60	+1.0
2	18	35	+4.2	+1.9	42	+1.5	+0.6	3	−1.0	–	–
2	19	28	+2.7	+1.5	53	0	0	–	–	30	+1.7
2	20	35	+2.2	+1.0	35	+1 2	+0.5	–	–	–	–

TABLE I—CONT'D

GROUP	CASE	TIME WITHOUT INSULIN (DAYS)	WEIGHT CHANGE WITHOUT INSULIN (POUNDS)	AVERAGE DAILY WEIGHT CHANGE (OUNCES)	TIME ON INSULIN (DAYS)	WEIGHT CHANGE ON INSULIN (POUNDS)	AVERAGE DAILY WEIGHT CHANGE (OUNCES)	STAY AFTER STOPPING INSULIN (DAYS)	WEIGHT CHANGE AFTER STOPPING INSULIN (POUNDS)	TIME OF OBSERVATION AFTER DISCHARGE (DAYS)	WEIGHT CHANGE AFTER DISCHARGE (POUNDS)
2	21	25	+2.7	+1.7	28	+1.0	+0.6	–	–	45	+0.5
2	22	25	+2.7	+1.7	28	+1.5	+0.8	9	–0.5	45	+3.2
3	23				59	+4.0	+1.0	14	+0.5	–	–
3	24				70	+5.7	+1.3	–	–	30	+3.7
3	25				32	+2.2	+1.0	7	+1.0	15	+2.5
3	26		NO		70	+5.0	+1.0	–	–	60	–2.5
3	27		OBSERVATION		18	+2.5	+2.2	32	+3.7	–	–
3	28		BEFORE		63	+3.7	+0.9	–	–	–	–
3	29		INSULIN		56	+3.7	+1.0	–	–	120	+2.7
3	30				35	+5.2	+2.3	5	–1.5	–	–
3	31				64	+4.7	+1.3	–	–	–	–
3	32				18	+6.2	+5.5	28	+3.2	15	–2.0
4	33	53	+8.2	+2.4	14	+2.0	+2.2	0	–	–	–
4	34	15	+2.0	+2.0	21	+2.5	+2.0	7	+1.2	150	+4.5
4	35	103	+0.7	+0.1	70	+1.2	+0.2	14	0	–	–
4	36	21	–3.2	–2.4	42	+2.0	+0.8	3	+0.5	–	–
4	37	14	0	0	42	+1.0	+0.4	7	0	–	–
4	38	19	+0.2	+0.2	3	0	0	24	+2.0	–	–
4	39	46	+1.0	+0.3	14	–1.0	–0.9	0	–	15	+1.0

of these children for an average time of two months after discharge from the hospital. All but four patients showed increases in weight over the discharge weights; the average for the whole group being 1½ pounds total.

Table I shows the actual figures in each of the cases treated by insulin with the exception of two cases mentioned before in the fourth group. In Table I the weight gains are shown in pounds and ounces rather than percentages.

CONCLUSIONS

1. Insulin therapy is of real value in speeding up the rate of gain of undernourished children who do not respond satisfactorily to the usual hygienic and dietary treatment.

2. Insulin has very little, if any, effect upon the weight curve of children who are already gaining at a satisfactory rate. Therefore, insulin therapy should not be instituted until after a preliminary period of observation.

3. Insulin may be of value in checking the weight loss of chronic, low grade infections with fever.

4. The usual dosage of 5 units t.i.d. may have to be increased to obtain an effect in certain individual cases.

5. The administration of insulin subcutaneously, 20 minutes before meals, is a relatively safe procedure in children over three years of age and has a large margin of safety as regards dosage.

6. Very young children and infants do not react favorably to continued insulin therapy because of the frequency with which they are thrown into hypoglycemic shock.

7. Any weight gain that may be achieved by the use of insulin is maintained for at least two months.

REFERENCES

1. Pitfield, R. L.: New York M. J. **118:** 217, 1923.
2. Marriott, W. McKim: J. A. M. A. **83:** 600, 1924.
3. Tisdall, F. F., Brown, A., Drake, T. G. H., and Cody, M. G.: Am. J. Dis. Child. **30:** 10, 1925.
4. Barbour, O.: Arch. Pediat. **41:** 707, 1924.
5. Priesel, R., and Wagner, R.: Klin. Wchnschr. **4:** 489, 1925.
6. Buttenwieser, S.: Med. Klin. **18:** 659, 1925.
7. Vogt, E. S.: Zentralbl. f. Gynäk. **49:** 2652, 1925.
8. Mahnert, Alfons: Monatschr. f. Geburtsh. u. Gynäk. **74:** 347, 1926.
9. Katsu, Y.: Jap. J. Obst. and Gynec. **13:** 567, 1930.
10. D'amici: (Abstract) J. A. M. A. **95:** 1872, 1930.
11. Moutier, F.: Ann. de Med. **22:** 616, 1927.
12. Budde, O.: Ztschr. f. Kinderh. **45:** 303, 1928.
13. Freud, Paul: Wien. med. Wchnschr. **792:** 1171, 1929.
14. Appel, K. E., Farr, C. B., and Marshall, H. K.: J. A. M. A. **90:** 1788, 1928.
15. Hawley, E., and Murlin, J. R.: Am. J. Physiol. **75:** 107, 1925.
16. Unverricht, D.: Münch. med. Wchnschr. **24:** 1473, 1926.
17. Tillgren: Svenska läk.-sällsk. förhandl. **11:** 225, 1928.
18. Martenson, A.: (Abstract) J. A. M. A. **93:** 814, 1929.

19. Mascher, W.: Svenska läk-tidning **26**: 1321, 1929.
20. Leggett, E. A., and Callahan, F. F.: Lancet **51**: 563, 1931.
21. Barker, L. F.: Internat. Clin. **3**: 19, 1931.
22. Marin, J., and Bouessee, F.: Ann. de Med. **22**: 308, 1927.
23. Spickard, V. W.: Northwest Med. **26**: 282, 1927.
24. Gillespie, G. Y.: South. M. J. **21**: 834, 1928.
25. Davidson, C. F.: Northwest Med. **28**: 564, 1929.
26. Metz, R. D.: J. A. M. A. **96**: 1456, 1931.
27. Idem: Ann. Int. Med. **6**: 743, 1932.
28. Stites, F. M., and Stites, J.: Kentucky M. J. **30**: 606, 1932.
29. Jones, O. S.: J. Missouri M. A. **29**: 416, 1932.
30. Okada, S., et al.: Arch. Int. Med. **43**: 446, 1929.
31. Quigley, J. P., Johnson, V., and Solomon, E. I.: Am. J. Physiol. **90**: 89, 1929.
32. Feissley, R.: Presse méd. **34**: 196, 1926.
33. Schellong, F.: Münch. med. Wchnschr. **24**: 1641, 1926.
34. Osato, S.: (Abstract) J. A. M. A. **87**: 1165, 1926.
35. Bürger, M., and Rückert, W.: Ztschr. f. Physiol. Chem. **196**: 169, 1931.
36. Wilson, J. R., Levine, S. Z., and Gottschall, G.: Am. J. Dis. Child. **36**: 470, 1928.
37. Goldblatt, M. W., and Ellis, R. W. B.: Biochem. J. **25**: 221, 1931.
38. Long, M. L., and Bischoff, F.: J. Nutrition **2**: 245, 1930.
39. Macleod, J. J. R., Magee, H. E., and Middleton, W.: Biochem. J. **24**: 615, 1930.

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ACTIVE IMMUNIZATION AGAINST SCARLET FEVER BY THE NASAL ROUTE

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MUCH progress has been made since the early efforts of Gabritschewsky[1] in the development of an effective procedure for the immunization against scarlet fever.

The discovery of the Dicks[2] in 1924 established the relationship of the hemolytic streptococcus to scarlet fever and provided a test for susceptibility to this disease.

The Dicks,[3] by using raw toxin in five increasing doses, have been able to establish immunity in from 90 to 95 per cent of the children. This immunity persists for at least two years. Various investigators, including Platou,[4] Park,[5] Benson and Simpson,[6] Kiefer,[7] Peavis,[8] and Melnick,[9] using the same or a smaller number of injections with varying amounts of toxin, have confirmed the effectiveness of this method of producing active immunity to scarlet fever.

In recent years several different methods of active immunization have been attempted.

Scarlet fever toxin, partially detoxified by sodium ricinoleate and administered in from one to three doses, was prepared by Larson[10] and had been rather extensively used by him and by a number of other investigators.[11-16] Although the early reports were very favorable, the preparation has fallen into disuse, because the Scarlet Fever Committee found that the inoculations were accompanied by severe reactions and resulted in immunity of but short duration.

Since 1930, scarlet fever toxoid (toxin modified by formaldehyde) has been prepared and used by Futagi,[17] Mc Mahon,[18] Reed and Tellier,[19] and Veldee.[20] The toxoid is injected in three doses. The number of patients rendered immune ranged from 72 to 87.5 per cent with only an occasional general reaction.

Wide use of the Dick method of active immunization has not been witnessed because of the severity of reactions in from 10 to 20 per cent of the individuals and because of the large number of hypodermic inoculations required.

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Acknowledgment is herewith gratefully made to E. R. Squibb & Sons for furnishing the toxin used in this work.

In an endeavor to escape these drawbacks, the inunction, oral, and intranasal methods of inoculation have been evolved.

Martmer,[21] in 1932, using the Dick toxin in a lanolin base, reported immunity in 66 per cent of a group of 155 children with five applications per individual.

In a series of experiments, Cooke[22] found that the oral administration of toxin, even in amounts up to 2,500,000 S. T. D., produced no reduction in skin sensitivity to toxin, confirming the experience of the Dicks. Following the rectal instillation of highly concentrated toxin, he found a constant decrease in skin sensitivity, indicating a limited absorption of toxin through the rectal mucosa.

The intranasal method was first applied in 1927 by Zoeller and Ramon.[23] They had previously used diphtheria toxoid by this route with striking success. With a desiccated toxoid preparation they were able to immunize from 98 to 100 per cent of their subjects against diphtheria. Using Dick toxin in two series of instillations, they produced immunity in nine out of ten cases. Except for an occasional complaint of slight nasal stuffiness, no local or general reactions were encountered.

Peters and Allison[24] using scarlet fever toxin sprayed into the nose every other day for five weeks reported that 36 per cent of sixty-one individuals were rendered immune, and 39 per cent partially immune to scarlet fever.

Mme. S. Kostitch-Yoksitch[25] using 1,250 S. T. D. of scarlet fever toxin intranasally twice a day for seven days, or a total of only 17,500 S. T. D., reported that at the end of fourteen days every member of a group of thirty-two children had become immune to scarlet fever.

As may be gathered from a review of the literature active immunization against scarlet fever has failed to achieve popularity because the procedure involves five or six hypodermic injections. An equally significant obstacle to its use, except in institutions, is the severity of local and constitutional reactions. If immunization could be effected without recourse to needle and syringe and with a minimum of discomfort, it is a fair presumption that but few parents would interpose any objection to its application. Because of existing handicaps, relatively few children are afforded the benefits of a most valuable prophylactic measure.

It therefore appeared to us highly desirable to devise a method of administering scarlet fever toxin other than by the needle route. We had at this juncture not yet thoroughly familiarized ourselves with the various means of its application adopted by other observers, with a view of eliminating the needle. Its introduction by way of the nasal passages suggested itself, as it had to other workers in this field. The nasal mucosa is recognized as a common portal of entry for various pathogenic organisms and doubtless constitutes the route through which spontaneous immunity to many infections, including scarlet fever, is established.

Furthermore, various medicaments are known to be promptly and completely absorbed from its surface. The occurrence of an epidemic of scarlet fever in a sister institution furnished the immediate incentive for the experiment.

Accordingly, on May 4, 1933, fifty-six children at the National Jewish Hospital Preventorium were tested for susceptibility to scarlet fever. Thirty-one boys and twenty-five girls made up the group. The youngest children were four years old and the oldest, sixteen. Twelve children were between four and eight years of age; twenty-seven between eight and twelve; fourteen, between twelve and sixteen; and three were a trifle beyond sixteen. All the children were in good health and free from acute infections. About 50 per cent of their number had shown a positive tuberculin reaction. It was impossible to ascertain how many had had scarlet fever. Nearly all the children had undergone a tonsillectomy.

The reaction was inspected at the expiration of twenty-four hours by all three observers. The slightest redness, provided that the area measured 10 mm. or more in diameter, was interpreted as a positive reaction in accordance with the directions of the Dicks. The same precaution was observed in all subsequent testing by the Dick method. In only one particular had we deviated from instructions prescribed by the Dicks. Instead of dry sterilization of needle and syringe, we had resorted to sterilization in tap water in a few instances. However, all the water was expelled before toxin was drawn into the syringe.

Thirty-six children yielded positive and twenty, negative reactions. In doubtful cases, the test was repeated. Nineteen boys and seventeen girls comprised the positive group; and twelve boys and eight girls the negative contingency. In terms of percentages, 64 per cent of the children were susceptible to scarlet fever; 62 per cent of the boys, and 68 per cent of the girls reacted positively.

On May 11, thirty-four positive reactors, nineteen male and fifteen female, received their first inoculation. Each child was instructed to rid the nasal passages of accumulated secretions by means of vigorous blowing. The inoculation was made with the child lying on his back, the chin tilted upward. The toxin was gently sprayed alternately into each nostril, about six to eight puffs sufficing to expel the entire contents. The spraying was performed by means of the standard De Vilbiss atomizer equipped with a specially devised container which held just a trifle over 1 c.c. Care was taken not to allow the tip of the atomizer to impinge on the wall of the mucosa. Such contact would inevitably result in loss of toxin through the relief vent. The children were cautioned against sneezing for ten or twenty minutes following the instillation, and were kept flat on their backs during that length of time. Five inoculations were administered at weekly intervals. The respective dosages were

those prescribed by the Dicks for the subcutaneous injections, namely: 500, 2,000, 8,000, 25,000, and 80,000 skin test units. The inoculations were concluded on June 9. Needless to mention that the tip of the atomizer was sterilized before successive insufflations. Alcohol is not to be used for this purpose because of its precipitating effect on scarlet fever toxin.

The procedure gave rise to no discomfort other than a slight burning caused by the preservative. This complaint was trifling in nature and brief in duration and was most evident following the second instillation. No local or constitutional untoward effects were encountered. Not the slightest rise in temperature was noted.

The children who had been thus inoculated were retested by the Dick method on July 12, or five weeks after the last instillation. One-tenth cubic centimeter of the toxin was given for this purpose. Only twenty-five of the thirty-four children were available for the second Dick test. Six boys and four girls remained positive, and eleven boys and four girls showed a reversal to negative reaction. That is to say, we had succeeded in immunizing 60 per cent of the children against scarlet fever. These figures, however, do not reflect the full benefit conferred. A comparison of the initial with the final Dick test showed that in nine of the ten children who remained positive, the reaction was found greatly reduced in size and intensity. This indicates that these nine children, while not immunized to the point of yielding a negative reaction, had none the less been distinctly benefited by the inoculation.

The amount of toxin introduced by the nasal route, while sufficient to insure protection when given subcutaneously, proved inadequate in some, conceivably because of loss of some of the toxin or because of its partial neutralization by the nasal mucosa. We therefore resolved to administer the toxin by the same route but in considerably larger dosages, anticipating thereby an increase in immunizing effects. Through the courtesy of Dr. W. Wiley Jones, medical supervisor at the Colorado State Home for Dependent Children, the inmates of that institution were placed at our disposal.

On September 10, 1933, 278 children, 154 boys and 124 girls, were tested for scarlet fever susceptibility. Three were three years of age; forty-five, from four to eight years; 117, from eight to twelve, 101, from twelve to sixteen; and twelve, a trifle past sixteen. Fifty-eight children, twenty-five male, thirty-three female, or about 21 per cent, yielded a positive reaction. Of those under the age of eight years, thirteen, or 27 per cent, reacted positively; in the eight-to-twelve-year group, twenty-two, or 19 per cent; in the twelve-to-sixteen-year group, nineteen or nearly 19 per cent; and over sixteen, 25 per cent. Of the boys, 16 per cent were positive as compared with 25 per cent of the girls. It is thus apparent that the percentage of positives was higher

in the girls, and contrary to the usual experience, not consistently or appreciably higher in the younger than in the older group.

Of the fifty-eight positive reactors, forty children were selected for the inoculation—twenty-four boys, and sixteen girls. Five were under eight years of age; and thirty-five, between eight and seventeen years. The technic followed was identical with that practiced in the N. J. H. group, except for dosage. Here, likewise, five weekly inoculations were administered allowing a concentration of 2,000 skin test units for the first dose, administered Sept. 10, 1933, 10,000 for the second, 30,000 for the third, 80,000 in the fourth, and 80,000 in the fifth instillation, or a total of 202,000 skin test units, contrasting with 115,500 given to the first group. This group differed in one other essential from the preceding. Scarlet fever had appeared at this institution about six weeks prior to the commencement of inoculation and was not completely checked until about the middle of October. The character of the epidemic was mild, with but few minor complications. Provision for the complete and immediate segregation of all contacts, as well as of the stricken children, was available.

Following the second and third inoculations, nine of the older girls, domiciled in the same dormitory, complained of various symptoms, chiefly sore throat, and burning in the nose. No child presented a rise in temperature. Only in one was rest in bed deemed necessary. All symptoms disappeared within forty-eight hours. Among the younger children, no complaint of any kind was registered.

On November 11, four weeks following the last injection, thirty-four of the forty positive reactors who had received the full complement of toxin presented themselves for the retest. Four children had contracted scarlet fever after having received one or two inoculations, and two had left the institution. Of these thirty-four children, fourteen or approximately 41 per cent were still positive. The Dick test was again performed on November 25, or six weeks after the final inoculation, and this resulted in a reversal in four of the fourteen positive reactors, raising the percentage of the successfully inoculated to nearly 71. Of the ten inoculated children who remained positive, six showed a striking decrease in intensity of the reaction. This doubtless means that a considerable measure of immunity had been created, however, not quite sufficient to insure optimum protection.

The following observations deserve a few words of comment:

It was somewhat disconcerting to find a negative reactor, with the same technic and toxin, yielding four days later a positive reaction. We were equally chagrined to witness the development of scarlet fever in two of our negative reactors. Similar experiences encountered and commented upon by other observers clearly indicate that within certain limits, and

happily in but few individuals, the degree of immunity to scarlet fever as reflected by the intensity of the Dick reaction is subject to rather wide fluctuations.

It was reassuring to note that all the scarlet fever cases yielded a negative reaction from three to four weeks after the onset of the attack. We were equally gratified to find that seven untreated negative reactors again yielded, ten weeks later, a negative reaction.

Nine positive reactors were not inoculated because of the limited supply of toxin on hand. Ten weeks after the initial Dick test, five of these children yielded a negative reaction. During this interval they had remained symptom-free. It is our belief that uninterrupted residence in a scarlet fever infested environment may have provided an opportunity for the development of spontaneous immunity. It does not appear wholly illogical to conclude that those children who remained positive despite inoculation and notwithstanding continued residence in the same scarlet fever infected milieu possess a deep-rooted refractoriness to immunization—a propensity evinced by certain individuals toward various other infections or toward prophylactic procedures.

SUMMARY

Immunization against scarlet fever was undertaken in two groups of children, aged three to seventeen years, by means of instillation of toxin into the nasal passages.

The attempt was completely successful in 60 per cent and 71 per cent of the children, respectively, and partial immunity was conferred in a considerable percentage of the rest of the group.

The inoculation was not attended by any serious local or constitutional effects.

COMMENT

Exhaustive survey of the literature on active immunization against scarlet fever presents convincing evidence of the reliability of the Dick test as an index to immunity. It shows that active immunization can be achieved in a considerable proportion of children. Such review stresses the point that the necessity for from five to six injections—and according to recent experimentation possibly only three or four—and the severity of reactions hamper its widespread use, except in institutions. It shows that a very fair measure of immunity can be established by methods which do not necessitate the use of the needle. The endonasal instillation of toxin has been shown to produce immunization in a considerable number of cases and is unattended by noteworthy reactions. Personal experience justifies the belief that a still greater measure of success may perhaps be achieved by modifications in dosage, interval between inocula-

tions, or number of instillations. It is our opinion that the final Dick test should not be performed earlier than four weeks after the last inoculation.

RECOMMENDATIONS

It is highly desirable that active immunization against scarlet fever should be as widely practiced as is diphtheria immunization.

Until the prevailing method of immunization has been so modified as to eliminate unpleasant and severe reactions and the necessity for a large number of hypodermic injections, we recommend the intranasal instillation of toxin.

This method is clean, painless, and free from serious local and constitutional untoward effects, and has proved successful in a considerable number of cases.

The percentage of successful inoculations can be definitely enhanced by the administration of a sixth and even a seventh weekly instillation in those still positive at the conclusion of the fifth inoculation.

In children under three years of age we recommend, provisionally, a total of 115,000, and in those past three, 202,000 skin test doses.

REFERENCES

1. Gabritschewsky: Centralbl. f. Bakteriol **4:** 719, 844, 1906.
   Idem: Berl. klin. Wchnschr. **44:** 566, 1907.
2. Dick, Gladys, and Dick, George: J. A. M. A. **81:** 1166, 1923.
3. Dick, George, and Dick, Gladys: Am. J. Dis. Child. **38:** 905, 1929.
4. Platou, E. S.: Minnesota Med. **8:** 285, 1925.
5. Park, Wm. H.: J. A. M. A. **85:** 1180, 1925.
6. Benson, W., and Simpson, G.: Lancet **1:** 281, 1927.
7. Kiefer, G. L.: J. A. M. A. **91:** 1885, 1928.
8. Peavis, R. P.: Illinois M. J. **62:** 246, 1932.
9. Melnick, T.: Arch. Pediat. **50:** 158, 1933.
10. Larson, W., Huenekens, E., and Colby, W.: J. A. M. A. **86:** 1000, 1926.
11. Platou, E., and Collins, L.: Arch. Pediat. **43:** 707, 1926.
12. Stewart, C.: Journal-Lancet **46:** 305, 1926.
13. Perkins, R., and McGrail, E.: Ohio State M. J. **22:** 599, 1926.
14. Colby, W.: Minnesota Med. **8:** 568, 1925.
15. Lees, H.: J. A. M. A. **88:** 1133, 1927.
16. Goldberg, B.: Ohio State M. J. **24:** 44, 1928.
17. Futagi, Y.: J. Immunol. **19:** 451, 1930.
18. McMahon, H.: Am. J. Dis. Child. **39:** 66, 1930.
19. Reed, G., and Tellier, H.: Canad. M. A. J. **25:** 584, 1931.
20. Veldee, M.: Canad. Pub. Health J. **24:** 255, 1933.
21. Martmer, E.: J. PEDIAT. **1:** 555, 1932.
22. Cooke, J.: Am. J. Dis. Child. **45:** 54, 1933.
23. Zoeller, C., and Ramon, G.: Presse médicale **69:** 1049, 1927.
24. Peters, B., and Allison, S.: Lancet **1:** 1035, 1929.
25. Kostitch-Yoksitch, S. A.: Rev. franç. de pediat. **5:** 614, 1929.

LYZED GONOCOCCI IN THE TREATMENT OF GONOCOCCUS CERVICOVAGINITIS

Preliminary Report

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IN 1930, Herrold, Blatt, and Hoffman[1] reported observations on the biologic treatment of vaginitis. One phase of this work included subcutaneous and intracutaneous injections of filtrates made from five- to seven-day growths of gonococci. In some instances, there seemed to be definite benefit from this specific therapy but because such favorable results did not follow in a high percentage of cases, its use as a routine treatment did not seem justifiable. Many of these patients seemed cured both from a clinical viewpoint and by laboratory findings. Later some of these returned with exacerbations which, so far as could be determined, were apparently not reinfections.

A second phase of the work included the intracutaneous injection of viable gonococci, and the results were distinctly superior to the injection of gonococcus filtrate (toxin). It is possible that such improved results with the viable gonococci may have been due to the production of a more specific and more soluble antigen by the in vivo action of the body cells on the viable gonococci.

It is well known that a more complete lysis of bacteria occurs through the action of bacteriophage than follows spontaneous autolysis. Therefore in the series of patients herein reported, we have made use of an antigen that was prepared by the induction of complete lysis of gonococci in young broth cultures through specific bacteriophage action. This product called neiso-lysate* has seemed distinctly less toxic than the older broth cultures that were permitted to partially autolyze spontaneously, which we used in our previous observations. The clinical results with neiso-lysate as observed in this preliminary report seem definitely more favorable than that obtained by any previous biochemical treatment that we have used.

The authors believe that in the past many cases of gonococcus vaginitis in childhood have been considered cured when successive negative smears for gonococci were obtained from the vagina. The technic commonly used in taking these smears has been the insertion of cotton-covered applicators into the vagina from one-half to one and one-half inches. In our series of cases, it has been found that while such smears may be re-

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*Prepared in the Research Laboratory of Eli Lilly and Company.

peatedly negative, the presence of pus in the vault of the vagina and cervix is suggestive. The microscopic examination of smears from this pus often reveal active gonococcus infection. No case should be considered cured until the vault and cervix is free from both pus and gonococci. In spite of this more severe criterion of cure, recurrences in the control group were more frequent in the period of this observation than in the cases actively treated by neiso-lysate during a like period of time.

The laboratory observation of smears obtained from the vault of the vagina through the panendoscope is an important guide for the duration of treatment with neiso-lysate since we have found that there is an individual variability in the number of injections needed for cure. Treatment was continued by biweekly subcutaneous injections for a period of from three to five months. An initial dose of 0.05 c.c. was gradually increased to an average maximum of 2 c.c. Occasionally a larger dose was given with no untoward effects.

When the initial dose was under 0.2 c.c., only slightly local and no general reactions were noted. Tolerance was seemingly increased during the course of injections since later comparatively large doses could be given without producing disagreeable reactions.

The control group consisted of eight children from six months to two and one-half years of age with gonococcus cervicovaginitis. They were under hospital observation with opportunity of reinfection eliminated as far as possible. All had a recurrence of active gonococcus infection following clinical cures as evidenced by successive cervical and high vaginal negative smears. The period during which they were free from symptoms varied from two to four months.

A series of eleven children from six months to three years of age, including five previously in the control group, were treated with neiso-lysate. Nine of them have remained free clinically and without bacteriologic recurrence for an average period of five months. Both groups were treated locally with from 0.5 to 1 per cent of silver nitrate in a 10 per cent gelatin base.

SUMMARY

Bacteriophage lyzed gonococcus antigen has produced results through preliminary observations that indicate it to be an efficient agent in treatment of gonococcus cervicovaginitis in children. This product does not produce disagreeable local or general reactions. Nine of eleven patients treated have remained clinically and bacteriologically cured for an average period of five months while a control group not so treated had recurrences in every instance.

REFERENCE

1. Biologic Therapy of Gonococcus Vulvovaginitis, Veneral Disease Information, Vol. XI, No. 9, Sept. 20, 1930, U. S. Treasury Department.

INGUINAL HERNIAS IN PREMATURE INFANTS

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THAT inguinal hernias occur frequently in premature infants is the impression obtained from pediatric literature. Although this general statement is common, we have found no report of their actual incidence. Using as material for study 830 premature infants who have been discharged from the premature station of Sarah Morris Hospital to the graduate out-patient clinic, we undertook to determine the incidence of hernias in premature infants, to compare this with the incidence in full-term infants, to investigate the causes, and, if possible, to determine the best methods of treatment.

According to Sir Arthur Keith,[1] 44 out of every 1,000 infants (4.4 per cent) are crippled by rupture in their first year of life. These figures were obtained from the study of males in Liverpool and from MacReady's *Treatise on Ruptures* which Keith believes is the standard English text on the subject.

Herzfeld,[2] in a study of 16,250 new cases in the out-patient department of the Royal Hospital for Sick Children, Edinburgh, found 2,100 children with inguinal hernias, an incidence of 13 per cent.

Patterson and Gray[3] reviewed the records of 130,243 patients at the Hospital for Sick Children (Gt. Ormand Street, London) and found 1,018 children with hernia (0.8 per cent).

Berger[4] estimated the proportion of ruptures in the male as 1 in 14.9; in the female as 1 in 44.7; an average incidence of 4.54 per cent in both sexes.

In our group of 830 infants, thirty-eight developed inguinal hernias, an incidence of 4.8 per cent. These figures are in accord with those of Keith and Berger, lower than Herzfeld's and higher than those of Patterson and Gray.

In Ylppö's[5] classical paper, he states that inguinal and umbilical hernias are more frequently found in premature than in full-term infants, also that the smaller the infant, the greater the frequency of hernia.

Of the nine infants weighing under 1,000 gm., two had hernias (22.2 per cent); in the group of 107 infants from 1,000 to 1,500 gm., five had hernias (4.67 per cent); of the 339 infants weighing from 1,500 to 2,000 gm., eleven had hernias (3.25 per cent); of the 324 infants weighing between 2,000 and 2,500 gm., eighteen had hernias (5.55 per

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cent); while of the fifty-one infants weighing over 2,500 gm., only two had hernias (3.92 per cent). With the exception of the smallest weight group, Ylppö's statement is not in agreement with our findings. Umbilical hernias were present almost invariably in our series and are not being considered here.

TABLE I

RELATIONSHIP OF HERNIAS TO BIRTH WEIGHT

WEIGHT IN GM.	TOTAL NO. OF INFANTS	TOTAL NO. OF HERNIAS	PERCENTAGE WHO DEVELOPED HERNIA
Under 1,000	9	2	22.22
1,000-1,500	107	5	4.67
1,500-2,000	339	11	3.25
2,000-2,500	324	18	5.55
Over 2,500	51	2	3.92

A similar set of figures is found when considering relationship of hernia to the estimated age of gestation.

TABLE II

RELATIONSHIP OF HERNIAS TO AGE OF GESTATION

AGE OF GESTATION IN WEEKS	NUMBER OF HERNIAS
28 or less	2
29-32	9
33-36	20
37 or more	7

Thirty-one of our infants with hernias were males (82 per cent) and seven were females (18 per cent). These figures are in accord with various other reports of hernia in the infant as noted in Table III.

In the males, twenty were right-sided, five left-sided and six bilateral. In the females two were right-sided and four were left-sided. Of all the hernias, 58 per cent were right-sided, 26 per cent left-sided and 16 per cent bilateral. These also agree with other reports.

TABLE III

SEX INCIDENCES AND POSITION OF HERNIA

AUTHOR	NO. OF CASES	MALE (PERCENTAGE)	FEMALE (PERCENTAGE)	RIGHT (PERCENTAGE)	LEFT (PERCENTAGE)	BILATERAL (PERCENTAGE)
Patterson and Gray[3]	773	90	10	Male 62 Female 45	20 35	18 20
Fraser[3]		90	10	62	24	11
Coley[4]	56,980	84	16			
Pybus[3]		89	11	59	26	15
Herzfeld[2]	1,000	89	11			
Deutsch[6]	639	90	10	52.75	25.19	22.06
Malgnigne[4]	2,769	80	20			
MacReady[4]	21,795	89	11			

The age in months at which the hernias were first noticed is shown in Table IV.

TABLE IV

AGE IN MONTHS AT ONSET	NUMBER OF CASES
1	2
2	16
3	14
4	2
5	2
15	1
24	1

There are several factors that might lead one to believe, from the anatomic and embryologic points of view, that hernias should be more common in premature than in full-term infants. Because the peritoneal process formed by descent of the testicle should normally be closed at about term, prematurely born infants are believed by some to have potential hernias. Because our figures do not show premature infants more liable to herniation, we believe that either the peritoneal process is obliterated earlier, or else the open sheath is not sufficient to cause herniation without the presence of other factors. It is well known that in the last months of fetal life and in infancy, the internal and external inguinal rings are almost in direct line with one another, so that the inguinal canal runs through the abdominal wall at right angles, instead of at an oblique angle as in later life after the pelvis has become broader in its development and has drawn the internal inguinal rings laterally. Since this condition is present in all infants, at least up to several years of age, it plays no rôle in causing a higher incidence of hernia in premature infants.

We believe that other factors are more important exciting causes of hernias. Any condition producing increased intraabdominal tension on the immaturely developed musculature of the abdominal wall in premature infants may produce herniation through the weak spot, and, of these, phimosis was the most common.

Phimosis as a cause of hernia is a subject of considerable controversy. Kelley[7] states that hernias may be caused by perpetual straining at micturition. Herzfeld[2] noted in her large series that the great majority of male children with hernia have phimosis. Coley,[4] however, does not believe that phimosis has any influence in the production of hernias, and Morse[8] states that he has never seen a hernia caused by this condition. After observing several of these infants in the act of micturition, and noting with what difficulty a few drops of urine were forced through a pinpoint-sized preputial opening, we decided to employ circumcision as part of our conservative treatment, with gratifying results, as will be discussed later.

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TABLE V

CONTRIBUTING CAUSES

CAUSE	NO. OF TIMES OCCURRING
Phimosis	12
Constipation	6
Diarrhea	7
Cough	8
Pylorospasm (vagotonia)	3
Excessive crying	3
Anal abnormality	1

In our group, twelve infants had marked phimosis (32 per cent). This represented 39 per cent of the male infants. Six infants were constipated or had straining associated with defecation; one had a definite anal stricture; seven infants had diarrhea; eight were affected by severe coughing; three by repeated vomiting, and three by more or less constant crying.

True strangulation occurred in six of our thirty-eight infants (16 per cent). Of these, four were males and two were females. It is noteworthy that this complication occurred immediately after the original appearance of the hernia in four infants, six days later in one, and six weeks later in the remaining one.

Until recent years strangulation of inguinal hernias in infants was believed to be extremely rare. Nussbaum,[9] in twenty-five years' experience with 54,000 children, saw only two cases. Herzfeld,[2] in her consecutive series of 1,500 herniorrhaphies on children, found strangulation in only three cases. Fuld[10] reported only one case among 1,200 children examined for hernia at the Children's Clinic for Ruptured and Crippled. Frankau,[11] studying the case records from a large number of surgical charts in a collective investigation for the Association of Surgeons for Great Britian and Ireland, found thirty-eight cases in infants under two years of age among a total of 1,487 cases of strangulated hernias. Deutsch[6] noted twenty-nine incarcerated hernias in his series of 780 children operated upon. Krause,[12] at the University of Königsberg Surgical Clinic, has operated upon six incarcerated hernias in nurslings, all males. He believes the incidence to be as high as 10 per cent. Porter and Carter[13] estimate this complication at from 5 to 7 per cent. Numerous other isolated case reports scattered throughout the recent literature testify that the complication is not extremely rare.

Our six cases are summarized briefly in Table VI.

Fortunately in five of the six infants the complication was recognized early by the parents, and operation was followed by recovery. The other infant was very much dehydrated and moribund when first seen and died from shock five hours following operation.

Conservative treatment has been used for all uncomplicated hernias. Yarn trusses as devised by Fiedler and fully described by Hess[14] or soft rubber trusses have been applied to all infants, except those who have had immediate circumcisions.

Early in the care of these hernias the importance of phimosis was not impressed upon us. For this reason, four infants with marked phimosis were not circumcised. In three of these the hernia did not disappear until between two and five months after its initial appearance. In the fourth one strangulation occurred.

In eight infants circumcision was performed when the hernia was first noted. In five of these there was an immediate disappearance of the hernia; two disappeared within a few days; and one infant with

TABLE VI

DETAILS OF CASES OF STRANGULATION

CASE	AGE	SEX	LOCATION OF HERNIA	DURATION OF STRANGULATION	CONTENTS OF SAC	REPAIR	RESULTS	SURGEON
1	63 days	F.	L. Ing.	5 hr. known	L. ovary L. tube Part uterus	Bassini	Good	Goldberg
2	3 mo.	M.	R. Ing.	24 hr.	Cecum Appendix Term. ileum	Bassini	Good	Goldberg
3	48 days	M.	L. Ing.	24 hr.	Large bowel	Bassini	Died 5 hrs. P.O.	Crohn
4	2 yr.	M.	L. Ing.	14 hr.	Reduced spontaneously	Andrews	Good	B. Portis
5	2½ mo.	M.	R. Ing.	5 hr.	Ileum	Andrews	Good	Crohn
6	2½ mo.	F.	L. Ing.	12 hr.	L. ovary L. tube Uterus	Andrews	Good	S. Strauss

large bilateral irreducible hernias has improved markedly so that the masses are smaller and easily retained by a truss. The greater rapidity with which the hernias disappeared after circumcision was very striking.

Measures aimed at the removal of the other causes of increased intraabdominal tension have been used. Constipation has been treated by dietary means, anal constriction by gentle stretching or plastic repair and excessive crying by the use of luminal as a sedative after making sure that the hernia had been completely reduced. Meatotomy for an abnormally small urethral orifice may be necessary.

Strangulation has been classed as a surgical emergency. We hesitate to attempt any but the slightest taxis in manual reduction, fearing that the danger of injuring a viscus, or reducing a nonviable viscus, or reducing the entire hernia without releasing its constricting neck is considerable, even greater than the risk of radical surgical treatment. Our surgical results have justified such a stand.

Operative technic differs but little from that in adults. It must be modified because of the small size and delicacy of the structures. Ether has been preferred as an anesthetic because it is safe in good hands, because it seems to be a slight stimulant to these infants, and gives better relaxation. The repair may be any of the standard types. We favor the Bassini or Andrews operation without transplanting the spermatic cord. With the sac well isolated and ligated, little suturing of the abdominal wall is necessary, inasmuch as healing is very rapid. Plain catgut has been used throughout, even for the skin, and dressings of a small strip of gutta-percha sealed with collodion have proved most satisfactory. Preoperative and postoperative care is very important. Treatment of shock and dehydration are paramount. External heat, subcutaneous fluids, oxygen, and intramuscular blood have proved valuable adjuncts. The time in which these infants recovered was remarkably short.

There have been no signs of recurrence of the hernia in any of the babies treated either conservatively or by operation.

Of the entire group, one infant died following operation, three died later of ailments not relating to hernia, and two cannot be located.

The average time of disappearance of the hernia in those infants treated with trusses was two and one-half months. In contrast we have already shown the rapidity with which hernias disappeared in infants circumcised to correct phimosis.

COMMENT

If we may assume that Keith's figures for incidence of hernia in the first year of life (4.4 per cent) are representative, our finding of an incidence of 4.8 per cent is not sufficiently at variance to show that premature infants are more prone to inguinal hernia than full-term infants.

It is interesting to note that thirty-six of the thirty-eight infants developed hernias before reaching the age of six months. This corresponds to the findings of most authors that hernias are most frequently seen in infants before they reach that age.

We have observed that increased intraabdominal pressure from any cause is important as the exciting cause of hernia and treatment should be directed at eliminating such causes. Phimosis is, in our experience, undoubtedly a major predisposing factor. Circumcision should be an important part of the conservative treatment of hernias. Corrective measures for constipation, cough, crying, etc., plus the use of a truss have given uniform cures except where strangulation has occurred.

While we have not followed these babies long enough to determine whether they will develop recurrent hernias later, we have at least tided them over the period in life when surgery is probably most dangerous.

Interesting, although probably a coincidence, has been the presence of ovary, tube, and uterus in the sac of the strangulated hernias of both female infants. The more forward position of the ovary in late fetal life and early infancy undoubtedly accounts for this.

SUMMARY

1. Inguinal hernias have been found in thirty-eight infants in a group of 830 premature infants, an incidence of 4.4 per cent.

2. This incidence is similar to that reported in full-term infants.

3. The age of gestation or the birth weight of the infant were not found to be important factors, except that the smallest infants (under 1,000 grams) have developed a larger percentage of hernias than any others.

4. Males predominate in the incidence (82 per cent).

5. Fifty-eight per cent of the hernias in both sexes were right-sided, 26 per cent left-sided, and 16 per cent bilateral.

6. Increased intraabdominal tension resulting from phimosis, constipation, cough, tympanites, anal or urethral constriction, vomiting, crying, and breath holding, are important factors in the development of hernia. Immature development of the abdominal and intestinal musculature are contributory factors.

7. Treatment should be conservative. Trusses, circumcision, and meatotomy where necessary and elimination of other causes of increased intraabdominal pressure are the essential forms of therapy.

8. Strangulation is a complication calling for immediate surgical measures.

We wish to express our appreciation to Dr. N. N. Crohn of the Hernia Clinic and to the Urological Staff for valuable assistance and suggestions.

REFERENECS

1. Keith, Arthur: Brit. J. Surg. **11**: 445, 1924.
2. Herzfeld, Gertrude: Edinburgh M. J. **32**: 281, 1925.
3. Patterson, Donald, and Gray, George M.: Arch. Dis. of Childhood **2**: 328, 1927.
4. Coley, Wm. B., Keene's Surgery, Vol. IV, Philadelphia, 1908, W. B. Saunders Co.
5. Ylppö, A.: Ztschr. f. Kinderh. **20**: 212, 1919.
6. Deutsch, I.: Gyógyászat, 431, 1923. Abst. Internat. Abstr. Surg. **38**: 327, 1924.
7. Kelley, S. W.: Surgical Diseases of Children, St. Louis, 1929, The C. V. Mosby Co.
8. Morse, John Lovett: Clinical Pediatrics, Philadelphia, 1926, W. B. Saunders Co.
9. Nussbaum, A.: München. med. Wchnschr. **60**: 1434, 1913.
10. Fuld, Joseph E.: N. York M. J. **109**: 233, 1919.
11. Frankau, Claude: Brit. J. Surg. **19**: 176, 1931.
12. Krause, A.: Bruns. Beitr. zur klin. Chir. **121**: 361, 1921.
13. Porter, L., and Carter, W. E.: Management of Sick Infant, St. Louis, 1924, The C. V. Mosby Co.
14. Hess, J. H.: Premature and Congenitally Diseased Infants, Philadelphia, 1922, Lea & Febiger.

RAT-BITE FEVER

Report of Three Cases With a Review of the Literature

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FROM the time of the ancients, rats have been known to be carriers of disease. Reports of pestilence due to rodents have come from India long before the Christian Era. In ancient and medieval history, many pages have been written about the plagues usually associated with war, famine, filth, poverty, or a combination of all four, and though the name "rat-bite fever" is not mentioned, we might easily assume that it was seen many times by the doctors of those periods. Browning has immortalized the old German legend of the Pied Piper of Hamelin, who, in 1284 is supposed to have rid Hamelin in Prussia of its swarms of rats which were charmed by his piping into the River Weser.* The Black Death,[1] which descended on the world from 1348 to 1720, and which we know today as the bubonic plague, was carried by flea-infested rats. We read that in 1666 England was freed of this plague by another great disaster, the great fire of London which destroyed many rats and freed the city of them. With all these deaths and all this disease, which we know was due to rats, there must have been many cases of rat-bite fever. In our own literature, we have the first report of this disease in 1840 by Wilcox.[2] The most complete report in this country is by Bayne-Jones,[3] and in Canada, by R. Cameron Stewart.[4]

The disease is best known in Japan and China. The Japanese call the disease "sodoku" and we see this name used frequently in their literature. The causative organism, the *Spirochete morsus muris,* was first described by Kenzo Futaki[5, 6] and Kikutaro Ishiwara[7] in Japan in 1915. Many workers have tried to isolate other organisms in connection with the disease, most notable of whom was Tunnicliff,[8] who in 1918 reported finding a streptothrix in three cases. Anderson and Spector[9] reported a typical case of rat-bite fever in which a sporothrix-like organism was found. Recently, reports occur in the literature of the use of rat-bite fever inoculations for the thermic treatment of general paresis. This was first used by Solomon[10] in 1926 and later by Hershfield[11] and Teitelbaum.[12] However, this is still in the experimental stage and is not widely used.

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*The Pied Piper of Hamelin, the hero of an old German legend, a certain musician who, according to the legend, came in 1284 fantastically dressed to Hamelin in Prussia and offered for a sum of money to rid the town of rats which infested it. He charmed the rats by his piping, into the River Weser where they drowned. As the reward was withheld, he in revenge by his magic piping drew the one hundred and thirty children of the town to a cavern in a hill, which closed after them forever. Browning has versified the story.

The death rate from the disease, at one time high, has been greatly reduced by careful attention to early antiseptic care of such bites and by the treatment with the arsphenamines, a therapy first introduced by Hata[13] in 1912. Principally, the lower death rate is due to a world-wide campaign against rats.

We are reporting these three cases principally because the disease is rare and ordinarily overlooked by the general practitioner. Furthermore, certain of these rare diseases are not emphasized as much as they should be. Two of our patients ran courses which fit in perfectly with the most typical pictures of rat-bite fever as described in our textbooks of medicine.[14] The most important reason, however, for reporting these cases is because of our serologic findings which are different from any previously reported and, we feel, are of significance.

INCIDENCE

Bayne-Jones,[3] in his review of rat-bite fever in the United States, pointed out that eighty-one cases had been diagnosed rat-bite fever in twenty-three states. These were cases reported since 1840. We believe that the incidence of the rat bite itself and possibly rat-bite fever is much greater than that since we have had three patients with the disease in this hospital in less than a year and have had three other patients who were bitten by rats but did not develop rat-bite fever. No further statistics are available.

ETIOLOGY

The disease transmitted to humans by rats, usually the house or roof rat, is universal, carried by rats in all parts of the world. The cause of the disease has been found to be a spirochete, 2 to 5 μ in length, with one or more flagella at each end. Futaki[5] found organisms in the peripheral blood stream, in serum expressed from regional inflamed lymph glands, and in biopsies on rash-covered areas of skin to be described. They have also been found in rats, mice, and guinea pigs that have been inoculated with the blood of these patients. He has given the name *Spirochete morsus muris* or *Spirillum minus* to these organisms.

PATHOGENESIS

How these spirochetes are transmitted from the blood stream of the rat to that of man has been a disputed question as the organisms have never been found on the teeth or gums of the rats. Some men claim that the rat injures his gums in biting a person and that the blood of the rat is carried into the wound in this manner. The wound heals like any small cut or abrasion and is often forgotten during the incubation period, which may be from seven days to more than a month. Then the site of the bite begins to swell, becomes painful and tender, and soon ulcerates,

and, as Stewart[4] describes it, becomes chancrelike in appearance. There may or may not be a definite lymphangitis, but there is always regional lymphadenitis. The temperature rises rapidly to 105° or 106° F. There is a blotchy purplish red discoloration of the skin usually near the bite but at times found on other parts of the body. The patient is listless and irritable but has little or nothing else in the way of complaints.

The same day or following day the temperature falls to normal. That is, the stage of invasion is very short. The temperature remains normal four or five days; then everything flares up again with less severity though the temperature rises usually to 105° F. This attack usually is over in twenty-four hours, and the temperature is normal again for four or five days, when the attack recurs, and so on. The local swelling gradually disappears though there is always a scar as there is with a chancre. The lymphangitis disappears in a few days but the lymphadenitis persists for several weeks unless treatment is started early.

Usually the only manifestations late in the disease are the recurring elevations of temperature, coming every four or five days, reaching 104° or 105° F., and returning to normal on the same day. Occasionally the blotches of purplish red appear on the skin coincident with the rise in temperature. The patients, as a rule, are not very sick during their waves of temperature. The symptoms, however, may recur for months, but they can be quickly aborted by the use of one of the arsphenamines.

DIAGNOSIS

The history is that the patient was bitten by a rat. Arkin[15] reports a case of a rat which, instead of escaping, clung to the patient and had to be killed before it would release its hold. This patient later developed rat-bite fever.

The diagnosis is aided by the symptoms of localized swelling of the bitten area following the incubation period, which is followed by the lymphangitis, lymphadenitis, and the high temperature, then the clearing up of all symptoms within as short a period as from twenty-four to thirty-six hours, their milder recurrence (except the fever which rises to 105° or 106° F. in from four to five days), and again the disappearance of symptoms the same day. The diagnosis can be made on the temperature record; we have enclosed photographs of the records of two of the patients.

Every four or five days thereafter, the temperature rises rapidly to 105° or 106° F. and as rapidly, i.e., within from six to twelve hours, drops to normal. As a further aid, the Japanese investigators have isolated spirochetes in the primary ulcer, the lymph nodes, and the blood of their patients giving all the positive findings. We have not been so fortunate in our cases. We have found that all our patients developed

a weakly positive Wassermann and a strongly positive Kahn reaction during the febrile period and that this persisted for several months unless treatment was continued. Eventually all serologic tests become negative again. No other workers have reported similar findings.

TREATMENT

The treatment is simple. Local treatment of the wound when it is first seen may abort an attack. In addition we recommend locally calomel ointment or dusting powder, especially if seen late when the wound is chancrelike. As soon as the diagnosis of rat-bite fever is made from the history, typical onset, and fever record, we start administering to our patients sulpharsphenamine deep intramuscularly in the buttocks, giving the regular U.S.P. dose, and following Young's law for children. Five or six injections, given one week apart, usually will be sufficient for cure. On this treatment, our patients gradually improved, and were discharged apparently cured.

The following are the case reports:

CASE 1.—C. S., aged five years, was admitted to Children's Hospital on Aug. 23, 1933, with chief complaint of swelling, bluish discoloration, and slight ulceration of right index finger, and in addition, swelling of right arm and swelling and tenderness of the lymph nodes in the right axilla. This was his second admission to the hospital, the other having been for a period of a little over two months in 1930 for marasmus. He was a full-term baby, weighing 7¾ pounds at birth; delivery was normal. He was the seventh child; two of the others having died in childhood. His mother and father, as well as four brothers and one sister, were living at the time of his admission. He had had many feeding disturbances but no other illnesses. He showed the effect of his malnutrition at the time of his admission, for he was considerably underweight and backward in other ways.

The history of his present illness was that while playing in the coal shed four weeks previous to admission, he had been bitten on his right index finger by a rat. The wound was treated with a local antiseptic and apparently healed, but ten days later the finger began to swell. Local hot applications were applied. One week ago he was brought to our dispensary with swollen, slightly indurated red streaks running from the index finger to the axilla. The patient had a temperature of 104° F.

Other physical findings at this time included pulse of 110; normal respirations, hydrocephalic type of head; swollen left arm; first finger swollen and discolored purple with slight ulceration and induration. Motion was painful. The axillary lymph glands were very small but painful on palpation. The urine was negative. The white cell count was 13,600; there was a secondary anemia. The temperature dropped to normal on the day of admission and stayed down for four days. It then rose to 104.4° F., where it stayed for about four hours and by evening was again normal. It remained normal four days and again rose to 103.4° F. and then gradually fell again to normal in about the same length of time. Again the temperature went up three days later, this time only to 101.6° F., then was normal for two and one-half days. It then went rapidly to 106° F. and back to normal the same day. The temperature was the only marked symptom along with a rapid pulse. The respirations did not go up in proportion. Sometimes he was a little listless when the temperature was over 103° F. He ate well, did not vomit,

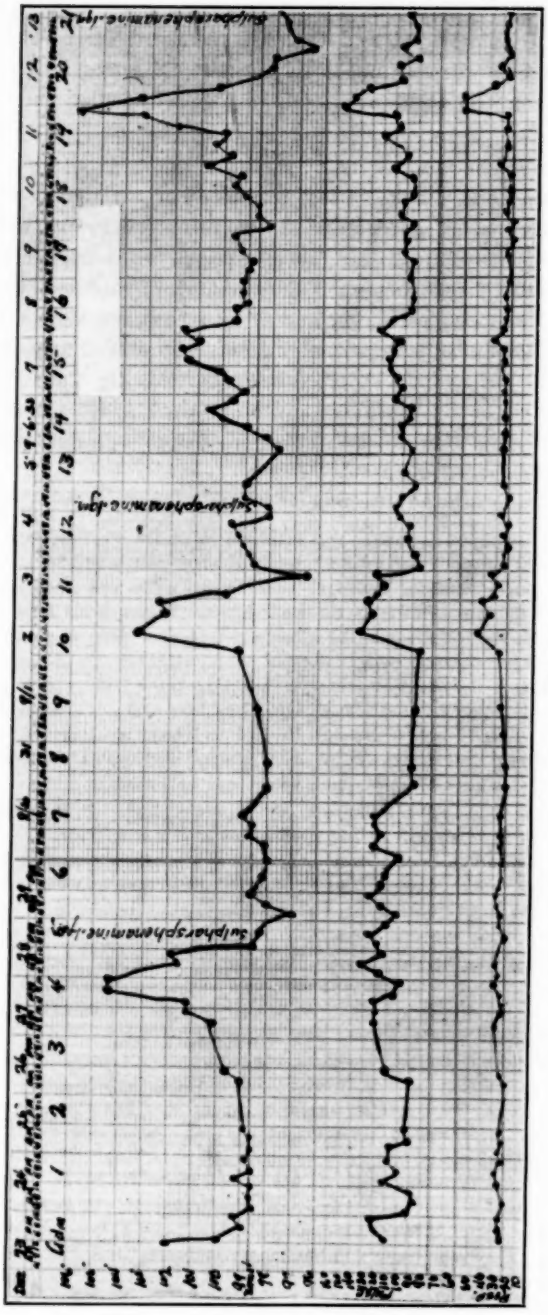

Chart 1.

and had no convulsions with the high temperatures. His body showed areas of red purple blotches, which were most marked at the time his temperature was up.

Since the patient was not at all sick but sat up in bed and ate well, we decided to discharge him from the ward and watch him in the clinic. His finger had healed, but a scar was left with a certain red purple discoloration. Glands were now palpable in the axilla. The Wassermann test was negative, and his Kahn reaction was two-plus. He was discharged improved on Sept. 15, 1933. Treatment had consisted of 0.1 gm. of sulpharsphenamine on three different occasions at intervals of one week. His mother at first thought he was doing well enough at home but on October 12, asked us to readmit him as she believed he was losing weight and running a fever. He had a low-grade upper respiratory infection at this time with cough and slight pharyngitis. No râles were heard in his chest. The patient had a temperature of 100.2° F. on admission; it remained down practically all the three weeks he was in the hospital except on one occasion when it went to 100.6° F. and came right back to normal. He had two small hard glands about the size of small grapes in his axilla. Permission was obtained to remove these; on October 27, these were excised. Sections stained with Levaditi's stains and also with hematoxylin and eosin showed chronic inflammatory tissue but failed to show any spirochetes. This wound healed well.

He gained weight. His color and disposition improved. While he never had been known to play before, he was quite playful at the time of his discharge on Nov. 2, 1933. He continued to do well in his follow-up in the clinic.

A study of his Wassermann and Kahn reactions and those of his sister on whom we are also reporting shows interesting findings. There was a negative Wassermann and a two-plus Kahn on his previous admission. The Wassermann and Kahn reactions were negative on admission, but on discharge, a one-plus Wassermann and four-plus Kahn were reported. Another test made a little less than a month after discharge gave a three-plus Wassermann and four-plus Kahn. Repeated dark-field examination of his blood failed to show any spirochetes, nor were any found in rats injected with his blood. Wassermann and Kahn tests made three months later were negative. Whether the removal of the glands could have had any effect on the way the positive blood tests cleared up without treatment is impossible to say. As shown by our second patient, positive Wassermann and Kahn reactions do not always become negative without treatment. Wassermann and Kahn tests have been run on the serum of the mother and father and all of the brothers and sisters. The only other one who gave a positive reaction is the sister, who is discussed in Case 2. We do not believe that there is a syphilitic infection in this family.

Case 2.—H. S., female, aged eight years, sister of our first patient, was brought to the Columbus Children's Hospital, Sept. 28, 1933, with the complaint that she was listless, underweight, and ran periodic fever. All these symptoms, according to the mother, dated about two months back, shortly after she was bitten by a rat, probably the same rat and at about the same time that her brother had been bitten. Her family history was the same as that of the patient in Case 1. There was no family history of tuberculosis or syphilis.

The patient had been perfectly well till she was bitten by the rat. No acute onset was noted as with the brother. The wound of the rat bite seemed to heal normally and left very little scar. About two months previous to admission, the mother noted that the patient was running a temperature periodically and also that she was listless, especially so at the febrile periods. She had lost her usual desire to play and seemed to be losing weight. Further, the mother had noted, periodically,

red purple blotches on her skin similar to those noted on her brother. The mother noted that the patient was passing a blood-tinged urine, though this history was not reliable.

On admission she was found to be a pale, frail, white female child of about the stated age, appearing somewhat underweight, but not acutely ill. Her head, eyes, ears, and nose were negative. She had a clean tongue, small tonsils, and several carious teeth. She had definitely palpable anterior cervical lymph glands. Her heart and lungs were negative. Liver or spleen was not palpable; genitals were negative. There was a scar on her back where, the mother stated, the rat had bitten her. She had a large red purple blotch on her back that was not elevated, warm, or tender. Her blood count showed a secondary anemia and practically a normal white count. Her urine was entirely negative.

A provisional diagnosis of rat-bite fever was made although from the history she was put down as suspected of having tuberculosis. She had several negative Mantoux reactions with material that gave positive reactions in other persons; consequently, we felt that tuberculosis could be very well ruled out especially in the absence of any lung or gastrointestinal symptoms. Her course in the hospital was uneventful. She did not run the periodic fever that our other patients had. Her appetite improved and her listlessness was not so marked. She gained very little weight. Treatment was nutritional, with Fowler's solution being given as a tonic. Since our experience in the treatment of rat-bite fever was limited at the time, and as the patient did not run a fever, no arsphenamine was given, and the patient was discharged improved, Oct. 4, 1933.

Our principal reason for reporting this case was because of the serologic findings. A blood test shortly after admission, and a little over two months since she had been bitten, showed a one-plus Wassermann and a four-plus Kahn reaction. This was checked, and a negative Wassermann and a four-plus Kahn were returned.

The patient left the hospital with instructions to return in one month for a repetition, but she did not return for four months. At this time the Wassermann reaction was two-plus and the Kahn, three-plus. The patient has been ordered into the Luetic Clinic of the hospital and to receive weekly treatments for six weeks with sulpharsphenamine, and then a blood test will be repeated after a one-month rest. If this is negative, she will be rechecked every month for six months, then every six months for two years. We feel if her blood tests are negative over this period, the dangers of recurrence are past.

CASE 3.—M. L. F. was admitted to the Columbus Children's Hospital on Dec. 18, 1933, with the history of having been perfectly well until Oct. 13, 1933, when she was bitten on the right index finger by a rat. The child had thought that the rat was a kitten when it approached her, and had put out her hand to pet it when it bit her. She was brought to our out-patient department and was given first aid the same day. She was also given tetanus antitoxin at the same time. The wound apparently healed.

Three weeks before admission, a little less than two months after the bite, the mother noted listlessness of the child and a slight fever. The child complained of slight pain, and the mother noted swelling of the finger that had been bitten. She also noted swelling in the axilla. The child was taken to a private physician who ordered wet compresses to the finger and about one week later made a small incision at the site of the original wound. During a two-week period of treatment with compresses, the patient was quite listless, ran a periodic temperature of which we have no record, and seemed to be quite sick.

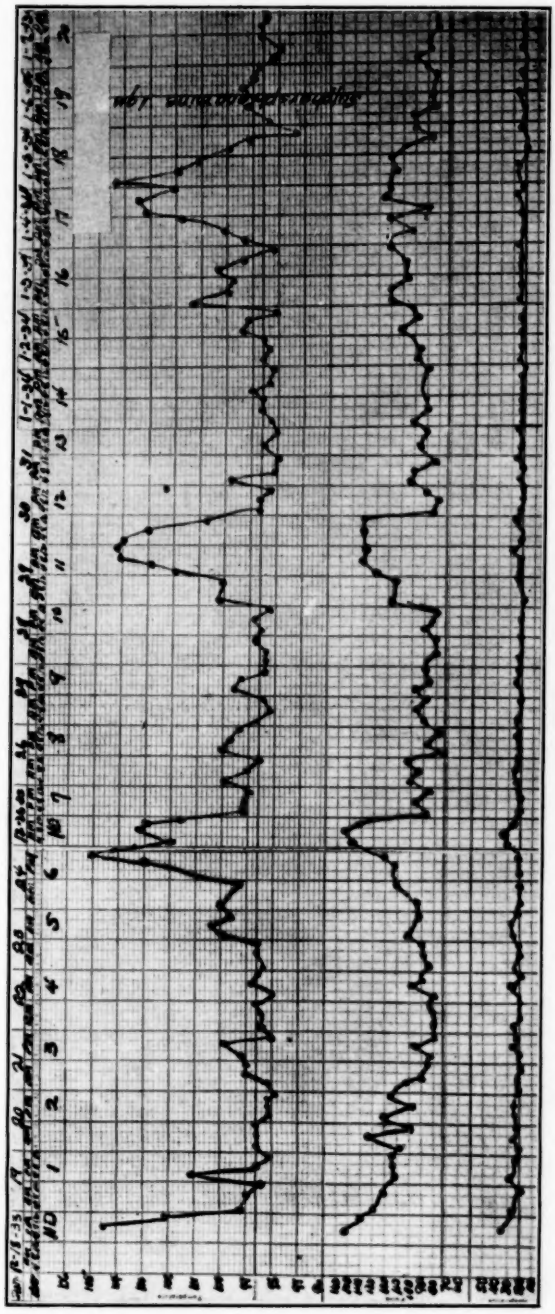

Chart 2.

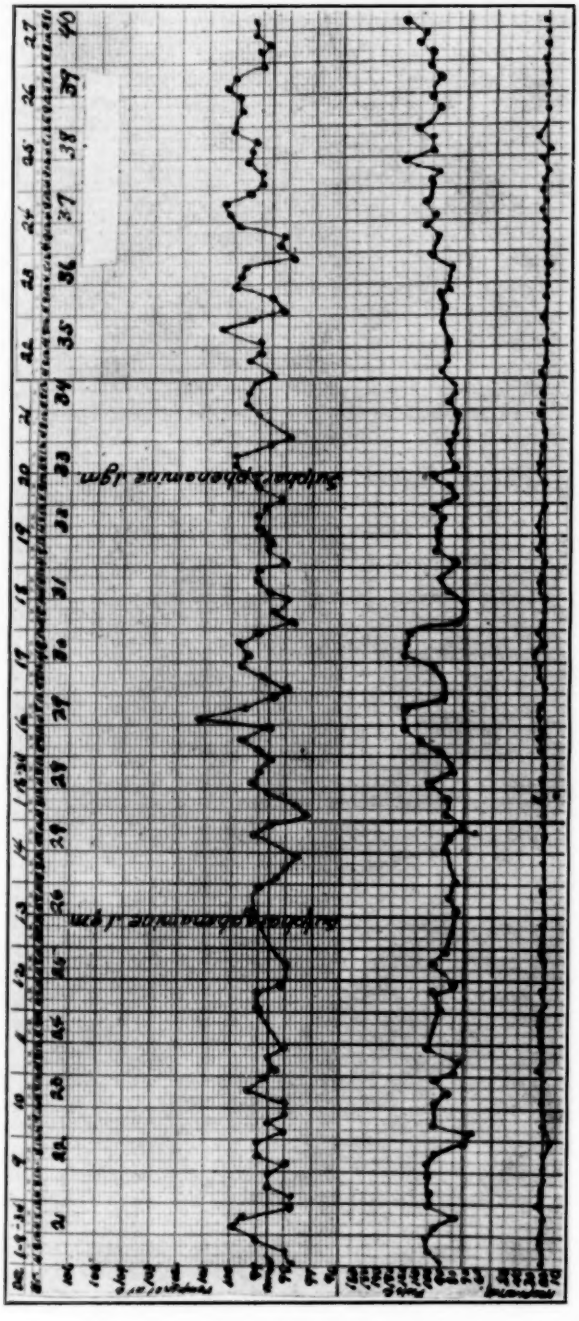

Chart 3.

On admission to the hospital, her temperature was 105° F. She was listless and complained of a pain in the axilla. The index finger and the palmar surface of her right hand were swollen.

There was a small incision at the base of the finger from which exuded a serosanguineous matter. There was a large tender gland in the axilla, which was somewhat red. Smaller glands, not tender, were noted in other axilla and in both inguinal regions. A large red blue blotch was seen on the left thigh. All other physical findings were negative.

From the history and physical findings, a diagnosis of rat-bite fever was made. A dry dressing was put on the finger and hand, and an ice bag to the axilla. The next morning the temperature was normal, and the patient appeared brighter. The temperature remained down for five days except for a slight rise on the evening after admission.

During this period, the patient was brighter; her finger and palm seemed to heal, and the gland in the axilla seemed to become smaller and less painful. Blood was taken at this time and sent to the Laboratories of the Department of Bacteriology at Ohio State University and the Ohio State Board of Health for dark-field examinations and injections into white rats and guinea pigs. No spirochetes were found in her blood. The urine was negative. The blood count was 16,500 with a secondary anemia. On admission, both the Wassermann and Kahn reactions were negative. In a repeat test a little over a week later the Wassermann was anticomplementary, and the Kahn reaction was four-plus. Three weeks later there was a two-plus Wassermann and three-plus Kahn reaction in spite of the treatment described below. The patient ran a periodic temperature, the chart of which is shown. Every four or five days it would go rapidly to 104° or 105° F. and drop on the same day. The patient would be listless during her febrile periods, otherwise she had no complaints. The wound on her finger healed leaving a blue purple scar; the gland in the axilla became smaller.

In an effort to isolate the spirochetes, which we felt were in the child's blood stream, we did not start treatment with sulpharsphenamine until Jan. 6, 1934. During this time, several unsuccessful dark-field examinations of the child's blood were made.

From the time treatment was begun until her discharge on Jan. 26, 1934, the patient only once ran a fever, and this time to only 101° F. Sulpharsphenamine was given in 0.1 gm. doses weekly until her discharge and was being continued at home. Her Wassermann and Kahn tests were positive three-plus and four-plus at the time of discharge. The patient did not return for two months; when she did, her Wassermann test was negative and her Kahn, two-plus. Treatment will be continued in the clinic as it is with the other patients. There was never a question of congenital syphilis in this case, as the family and personal history were entirely negative, and the blood of both parents gave negative Wassermann and Kahn reactions.

SUMMARY

1. Three cases of rat-bite fever are reported because of their rarity, their unusual symptoms, and serology.

2. All three gave histories of having been bitten by a rat; and two had typical local swelling, lymphadenitis, typical recurring periodic temperatures. All had positive Kahn and Wassermann reactions during the height of their illness. Two improved under sulpharsphenamine treatment and were discharged as cured and with negative serology. One

patient did not report back until recently when the Wassermann and Kahn reactions were positive. She will receive further treatment. No claim is made that all cases will show a positive serology.

3. Any form of arsphenamine may be used in treatment. We prefer sulpharsphenamine for use in children. The prognosis is excellent under a very short period of treatment.

4. We believe that rat-bite fever occurs more frequently than is generally believed and should be brought to the attention of the profession.

REFERENCES

1. Tobey, James A.: Riders of the Plagues, New York, 1930, Charles Scribner's Sons.
2. Wilcox, W.: Am. J. M. Sc. **26**: 245, 1840.
3. Bayne-Jones, S.: Internat. Clin. **3**: 235, 1931.
4. Stewart, R. C.: Canad. M. A. J. **19**: 575, 1928.
5. Futaki, K.; Takaki, F.; Taniguchi, T.; and Osumi, S.: J. Exper. Med. **23**: 249, 1916.
6. Idem: J. Exper. Med. **25**: 33, 1917.
7. Garrison, F. H.: History of Medicine, Philadelphia, 1929, W. B. Saunders Co., 746.
8. Tunnicliff, R., and Mayer, K.: J. Infect. Dis. **23**: 555, 1918.
9. Anderson, N. T., and Spector, B. K.: J. Infect. Dis. **50**: 344, 1932.
10. Solomon, H. C.; Berk, A.; Theiler, M.; and Clay, C. L.: Arch. Int. Med. **38**: 391, 1926.
11. Hershfield, A. S.; Kibler, O. A.; Colby, S.; Koenig, M. T.; Schmid, O. W.; and Saunders, A. M.: J. A. M. A. **92**: 772, 1929.
12. Teitelbaum, A. D.: U. S. Veterans' Bureau Med. Bull. **6**: 263, 1930.
13. Hata, S.: München. med. Wchnschr. **16**: 854, 1912.
14. Osler, Sir Wm., and McCrae, Thomas: Principles and Practice of Medicine, New York, 1930, D. Appleton & Co.
15. Arkin, A.: Arch. Int. Med. **25**: 94, 1920.

SCARLET FEVER PREVENTION BY IMMUNIZATION

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DURING recent years the concept of a causal relationship between a certain strain of hemolytic streptococcus and scarlet fever has been gaining favor. Although considerable unanimity of opinion exists today with respect to the specific etiology of this disease; the method of preventing it by inoculations with a toxin derived from the scarlet fever strain of streptococcus is not being practiced widely. The failure to do this may be justified on the basis of the poor results that have been obtained following the administration of presumably inadequate doses of scarlet fever toxin. When the methods recommended by the Scarlet Fever Committee were used, the objections by patients to the impracticability of five doses, the occurrence of occasional reactions, and the doubt in the minds of many physicians were additional factors which contributed to the reluctance of many in advocating immunization to their patients.

A question which may be properly raised and must be answered before specific prevention can be urged is whether the method of immunization recommended by the Scarlet Fever Committee really has merit sufficient to justify its adoption.

The medical literature of the past ten years furnishes us with more or less data on over 50,000 inoculated individuals. Although a great many of the reported studies are lacking in detail and in proper controls, a sufficient number is suitable for analysis, so that we may arrive at fairly safe deductions relative to the protective value of inoculations with the Dick toxin.

In the present study a change in reaction of the Dick test has been discarded in favor of subsequent case incidence as a criterion of immunity. Cases collected from various sources as reported in the literature have been divided into three groups for tabulation as follows:

1. Those adequately immunized.
2. Those inadequately immunized.
3. The unimmunized controls.

Table I presents the most exacting trial of the toxin's efficacy. Here are collected the reports of persons who were known to be susceptible by previous test. All of these persons had a relatively high degree of exposure to infection and were observed over considerable periods of time. A compilation of these data reveals the fact that among more than 20,000 susceptible subjects inoculated in accordance

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with the recommendation of the Scarlet Fever Committee only one subsequent case was reported. The annual incidence of the disease was, therefore, 1.65 per 100,000.

TABLE I

SHOWING SUSCEPTIBLE PERSONS REPORTED IN THE LITERATURE WHO WERE IMMUNIZED ACCORDING TO THE RECOMMENDATIONS OF THE SCARLET FEVER COMMITTEE AND THE ANNUAL INCIDENCE OF SCARLET FEVER PER 100,000 AMONG THOSE IMMUNIZED

AUTHOR	SUSCEPTIBLES (BY TEST)	EXPOSURE	TIME OBSERVED	SUBSEQUENT CASES	CASES PER YEAR
Dick[1]	11,584	Internes and nurses	5 yr.	0	
Rhoads[2]	298	Nurses	3½ yr.	0	
Rhoads[3]	492	Epidemic	10 mo.	0	
Knights[4]	26	Nurses	1 yr.	0	
Kiefer[5]	Several Institutions	Institution	3 yr.	1*	0.33
Dudley[6]	17	Inst. Epidemic	2 mo.	0	
Park and Schroeder[7]	195	Institution	18 mo.	0	
Hektoen[8]	200	Nurses (cont. dis.)	9 yr.	0	
Park[9]	5,000	Institution	5 yr.	0	
Platou[10]	149	Nurses and children	3½ yr.	0	
Peacock[11]	35	Inst. Epidemic	2 mo.	0	
Blatt[12]	46	Inst. Epidemic	3 mo.	0	
Broadbent[13]	48	Nurses	4 yr.	0	
Radoye[14]	725	Institution	2 yr.	0*	
Boynton[15]	164	Nurses	4 yr.	0	
Veldee[16]	5 institutions	Institution	2 yr.	0	
Total	20,000+				
Annual case incidence per 100,000					1.65

*Preparation and dosage not entirely up to standard of Scarlet Fever Committee.

Some of the studies included in Table I did not specifically state the number of controls. For this reason the uninoculated group reported in Table II is much smaller, although the cases included are comparable with those listed in Table I, since they are from the same institutions. It is noteworthy that the control cases were not Dick tested and, therefore, represent a less susceptible group than the one in Table I. Among these individuals 178 cases of scarlet fever occurred during a period of several years' observation. The annual incidence per 100,000 computed from 1,938 of these which can be utilized statistically is therefore 2,317.

Table III is made up of 34,000 cases reported several years ago. These were not Dick tested and received preparations and doses of toxin which, in the light of our present knowledge, must be considered inadequate for immunity.

The comparative results indicated in the first three of the studies comprising this table are not sufficiently conclusive, as the cases were not tested and the controls were taken from estimated child population.

TABLE II

SHOWING UNIMMUNIZED CONTROL CASES REPORTED AND THE ANNUAL CASE INCIDENCE OF SCARLET FEVER PER 100,000 POPULATION AMONG THE UNIMMUNIZED

AUTHOR	SUSCEPTIBILE AND IMMUNE SUBJECTS (NO DICK TEST)	EXPOSURE	TIME OBSERVED	SUBSEQUENT CASES	CASES PER YEAR
Dick	---	Internes and nurses	5 yr.	(37)	(7.4)
Rhoads	182	Internes and nurses	3½ yr.	15	4.3
Rhoads	206	Epidemic	10 mo.	11	13.5
Kiefer	---	Institution	3 yr.	(10)	(3.3)
Dudley	23	Institution epidemic	2 mo.	2	12.0
Hektoen	516	Contagious disease nurses	10 yr.	40	4.0
Platou	861	Contagious disease attendants	6 yr.	55	9.2
Boynton	150	Nurses	4 yr.	8	2.0
Totals	1,938				
Annual case incidence per 100,000					2,317

TABLE III

SUBJECTS IMMUNIZED WITH MODIFIED FORMS OF TOXIN NOT IN ACCORDANCE WITH THE RECOMMENDATIONS OF THE SCARLET FEVER COMMITTEE

AUTHOR	NUMBER INJECTED	EXPOSURE	TIME OBSERVED	SUBSEQUENT CASE INCIDENCE	
				INOCULATED	CONTROLS
Harrington[17]	9,158	Schools	5 yr.	64 (0.6%)	1.8% in 96,000 estimated child population
Brokman[18]	7,887	Schools	----	30 (0.4%)	1.09% in 63,900
Brokman[19]	16,345	Schools	18 mo.	60 (0.37%)	1.26% in 90,000
Lichtenstein[20]	82	Institutions	5 mo.	1 (1.3%)	----------
Platou[21]	154	Nurses and children	15 mo.	8 (5.2%)	----------
Platou[22]	601	Nurses	6 yr.	46 (5.0%)	9 (7% in 181)

In the last two studies, although the cases are comparable to those shown in the uninoculated group in Table II, it is evident that no significant difference exists in the results. Likewise, the difference between the inadequately inoculated series and the controls is not significant.

The most convincing evidence to me regarding the merit of adequate immunization is found in a study of nurses from the Central School of Nursing at the University of Minnesota. One hundred and sixty-four susceptible nurses (Table I) were inoculated according to the recommendation of the Scarlet Fever Committee. Not one of these has had scarlet fever during a period of four years, whereas eight out of one hundred and fifty nontested affiliate nurses (Table II) have contracted the disease during the same period of time. Since both do similar work in their apprenticeship on the scarlet fever wards, they are particularly comparable.

It would seem from the evidence available to date that graduated doses of pure scarlet fever toxin administered to the point of a negative Dick test are warranted in spite of certain objections which operate to prevent their widespread use. The practice of immunization against scarlet fever for the prevention of institutional epidemics seems particularly valuable.

REFERENCES

1. Dick, G. F., and Dick, G. H.: Am. J. Dis. Child. **38:** 905, 1929.
Idem: Kentucky M. J. **29:** 172, 1931.
2. Rhoads, Paul: J. A. M. A. **97:** 153, 1931.
3. Idem: J. Iowa M. Soc. **21:** 443, 1931.
4. Knights, E. M.: J. Lab. and Clin. Med. **14:** 614, 1928-1929.
5. Kiefer, G.: J. A. M. A. **91:** 1885, 1928.
6. Townsend, J.: Boston M. and S. J. **196:** 612, 1927.
7. Park, W. H., and Schroeder, M.: A. J. Pub. Health **18:** 1455, 1928.
8. Hektoen, L.: J. A. M. A. **102:** 41, 1934.
9. Park, W. H.: Personal communication.
10. Platou, E. S.: Minnesota Med. **15:** 697, 1932.
11. Peacock, S.; Werner, M.; and Colwell, C.: Am. J. Dis. Child. **44:** 494, 1932.
12. Blatt, M. L.: J. A. M. A. **98:** 1437, 1932.
13. Broadbent, J.: Lancet **2:** 823, 1932.
14. Radoye, T.: Rev. d'hyg. **52:** 94, 1930.
15. Boynton, R.: Personal communication.
16. Veldee: Pub. Health. Rep. **48:** 549, 1933.
17. Harrington, F. E.: Personal communication.
18. Brokman, Henryk: Kinderärztl. Praxis **2:** 200, 1931.
19. Idem: Ibid.
20. Lichtenstein, A.: Acta Paediat. **10:** 543, 1930-1931.
21. Platou, E. S.: Minnesota Med. **15:** 697, 1932.
22. Idem: Ibid.

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Critical Review

METHODS OF TESTING THE HEARING IN INFANTS AND YOUNG CHILDREN

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STUDIES to determine the auditory acuity of children may be roughly classified into two groups. The first contains the reports of tests made on children who have already acquired language, either spoken, written, or sign, and who are able to comply with the instructions of the examiner. The second group contains those who are unable, through language deficiencies, to comply with such instructions. Each group requires different armamentarium and technic, and obviously the information secured depends on the thoroughness of the tests. With the recent development of better equipment and more refined technic, more comprehensive information is being secured at the present time than could have been obtained at the time the older studies were made.

The first group of these studies contains the reports of all tests which have been made on school children. It is an observation older than the science of otology and our present school systems that children fail to make normal educational progress because they do not hear as well as their associates in the classroom. Teachers untrained in the observation of sensory handicaps note only their lack of attention, their apparent dullness, and their universal tendency to repeat grades. The problem so far as the school administrator is concerned is chiefly an economic one. On the other hand, when these studies are done under the supervision of a competent otologist, they present an entirely different aspect and involve the problems of preventive medicine.

These studies have attracted otologists for many years. Weil[38] of Germany writing in 1880 described his examination of 267 children, 30.3 per cent of whom had impaired hearing. Again in 1882[39] after examining the ears and hearing of 5,905 children, he stated that he knew of but one other study, that done by Reichard of Riga, who examined the hearing of 1,055 children, 22.2 per cent of whom heard the sound of a watch tick poorly. In America the first comprehensive study was that by Worsell,[41] who tested 491 children and found that seventy-two had bilateral impaired hearing and fifty-three others, unilateral impaired hearing.

Chrisman[8] wrote a most comprehensive survey of the studies which were done prior to 1893. Because of the thoroughness of this survey, of which he modestly writes, "It is pretty certain that no attempts have been made further than are recorded in this paper," and because

From the Oscar Johnson Institute, Department of Otolaryngology, Washington University School of Medicine.
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of his excellent bibliography, this paper is quoted rather freely. He mentions the following studies relating to tests of the hearing of school children: Sexton (1881) tested 570 children in the schools of New York City; in 1883 Worsell (noted above) tested 491 children in the Terre Haute, Ind., schools; Barr tested 600 children who were attending school in Glasgow, of whom 27.66 per cent were hard of hearing; Moure, in Bordeaux, tested two groups of children numbering 3,588, of whom 616 had defective hearing; Gellé tested children in an orphans' home and in the schools of the first order in Paris; Weil (noted above) tested 5,905 children in Stuttgart; Bezold examined 1,918 children in Munich; and Reichard (see above), Lunin, and Zhermunski examined children in Russia. One of the most interesting of these reports is that by von Gossler, Prussian Minister of Education, who in 1885 ordered that tests of the hearing of all pupils in the higher and preparatory schools of Prussia be done and found that 2.18 per cent of those in the higher schools, and 1.8 per cent of those in the preparatory schools were hard of hearing. Chrisman gives the details of method and technic. The tests were conducted using spoken and whispered words, the watch tick and Politzer's acoumeter. Needless to say, the wide differences of the vocal quality of the spoken and whispered words of different languages and the varied conditions under which the tests were made render the studies only roughly comparable. For example, one investigator required a room 30 meters long in which to conduct the tests. Another complained of a lack of cooperation on the part of the school authorities. A third had difficulty in securing conditions of quiet. In spite of these deficiencies, the studies were, in each instance, of great value in classifying the pupils for educational work. The use of the tuning forks had not become universal. The limitation of the frequency range of the spoken and whispered words was not fully understood. One must realize the enormous expenditure of time and energy in conducting these tests. We are led to think they were done with accuracy and precision and, although the tests may have been different, practically all were individual tests done under conditions which as nearly as possible approached the ideal. As late as 1916, according to Yearsley,[42] the whispered voice was the standard adopted by the British Board of Education and the normal distance was 20 feet. Yearsley reports a study by Love in which he found that 31.4 per cent of 194 children were hard of hearing. Goldstein[16] in 1931 states the probable reason for discontinuing these tests: "The watch test, acoumeter, whisper, and conversational voice, and older methods for functionally testing the hearing were found to be inaccurate, uncertain, and cumbersome and occupied too much time and personnel." For twenty or thirty years after Chrisman's report there were few comprehensive studies of this character reported in the literature. School administrators and otologists probably realized the futility of expending time and energy in studies which gave so little practical return.

The invention of the phonograph by Edison appeared to give promise of a hearing test which could be standardized but, as is often the case with new apparatus in the scientific world, there was considerable skepticism. Lichtwitz[22] writing in 1890 states that the adaptation of this instrument for hearing tests "must be doubted until practical

invesigations are made regarding it." The simple fact that in its early form it was not universally accepted for this purpose indicates that it did not meet these requirements.

The invention of the telephone and its universal use offered a means for producing a sound which could be standardized and measured. The sonometer by Hughes,[20] the electric acoumeter by Urbantschitsch,[36] the audiometer by Stefanini,[33] and that by Seashore[30] are examples of efforts in this direction. However, very few studies of the hearing of school children were forthcoming, probably an indication of the impracticability of the instruments offered. One study deserves notice. Using Seashore's audiometer in 1902, MacMillan[23] conducted tests on 6,729 pupils from six to eighteen years of age in the Chicago public schools and found that 16.5 per cent were defective in one ear or both. In Seashore's audiometer the stimulus sound is produced in a telephone receiver by opening and closing an electric circuit. The sound produced is not unlike that of a watch tick.

One gets the impression in reading these reports that the reason why a greater number of these studies were not done was because the information secured was too meager to justify the effort and that the results were often contradictory. So we find Wolff[40] in 1890 working out the frequency characteristics of the sounds of the spoken voice, and Zwaardemaker[43] in 1907 says, "The lack of consistency in the results of testing aural acuity becomes viewed in a new light if the choice of words is undertaken in a more systematic fashion." It remained for Miller[24] to analyze the vowel sounds scientifically and, by so doing, to explain in part at least the lack of consistency in the published studies. Crandall and MacKenzie[9] later verified Miller's work.

The modifications of the phonograph by the engineers of the Bell Telephone Laboratories just prior to 1926 eliminated many of the objectionable features which were present in its earlier form. Briefly stated, through the use of the magnetic reproducer the stimulus sounds are produced in a telephone receiver; the scratching noises caused by the needle passing through the groove of the disc are largely eliminated; the voice quality is greatly improved; and as many as forty children may be tested at one time, the entire test requiring but twenty minutes.

Fowler and Fletcher[12] first described the use of the 4A audiometer, as the modified phonograph is called, at the meeting of the American Medical Association in April, 1926. Up to that time these writers had tested 4,112 children in various public schools in New York City and found that 14.4 per cent had defective hearing. Assuming that this average held for the entire school population, they computed the number of children with defective hearing in the public schools of the United States to be approximately 3,000,000. In 1928[13] after additional data had been secured they restated this conclusion.

Because of the general use of the 4A audiometer throughout the country, the technic of its use is here described in some detail. The children are seated at their desks in a quiet room, each with a receiver held at one ear. On the desk before each child is placed a blank form like that shown in Fig. 1. The children are instructed to write the numbers they hear through the receiver in the blank columns, begin-

ning with the column at the left. The numbers to be written at the top of each column are spoken in a rather loud voice, the loudness decreasing in steps of three sensation units as the bottom of the column is approached. Four trials for each ear are given on the phonograph disc, the first two by a woman's voice and the last two by a man's. When the four trials are completed, the telephone is placed at the other ear, and the process repeated using the opposite side of the phonograph disc.

NAME_____
AGE_____
GRADE_____
DATE_____

DO NOT MAKE ANY NOISE AS IT WILL SPOIL THE TEST

INSTRUCTIONS

YOU WILL HEAR NUMBERS SPOKEN BY A PERSON WHO IS MOVING AWAY FROM YOU. THE VOICE WILL GET WEAKER AND WEAKER. LISTEN CAREFULLY AND WRITE AS MANY NUMBERS AS YOU CAN.

Hearing Loss	RIGHT EAR				LEFT EAR				Hearing Loss
	1	2	3	4	5	6	7	8	
30	54	56	85	64	48	55	48	38	30
27	41	68	83	46	23	54	63	43	27
24	84	63	42	42	66	88	83	52	24
21	51	14	18	82	41	42	32	57	21
18	18	34	61	21	81	23	85	22	18
15	23	12	35	15	68	85	63	56	15
12	22	31	32	35	21	86	18	65	12
9	11	63	44	46	15	64	24	25	9
6	48	88	53	41	43	58	88	16	6
3	98	81	66	53	31	38	25	84	3
0	66	26	22	52	24	18	62	32	0
−3	51	12	45	84	56	23	92	64	−3
	HEARING LOSS____				HEARING LOSS____				

HISTORY

DID YOU EVER HAVE AN ACHE OR PAIN IN YOUR EAR?_____ WHICH EAR?_____ WHEN?_____

DID YOU EVER HAVE A RUNNING EAR?_____ WHICH EAR?_____ WHEN?_____

DOES IT RUN NOW?_____

DO YOU EVER HAVE NOISES IN YOUR EAR, LIKE BUZZING, HISSING OR ROARING?_____

WHICH EAR?_____ WHEN?_____

P-34058

Fig. 1.

Naturally there are certain limitations to this test. Among these are: first, the use of the spoken voice for the stimulus limits the test to the range covered by the spoken voice; second, its use, at least in group tests, is limited to those children who are sufficiently advanced in their school work to be able to write the numbers as they hear them, i.e., to those in the latter part of the second or in the third grade; third, the loudest words used in the test are spoken with an intensity of but thirty sensation units, and there is no measure of

acuity for those having a greater loss; fourth, its use has, up to the present, been limited to the English-speaking people; fifth, only the monosyllabic numbers from one to eight are used as test words (this still further limits the range covered, but this disadvantage is probably more than compensated by the fact that it is not necessary to be able to spell the stimulus words); sixth, since all groups cannot be tested under identical conditions, a normal must be computed for each group.

The use of spoken words is of much greater value, so far as educational prognosis is concerned, than tests with the whispered voice, the watch tick, or the acoumeter, because the spoken voice is the medium through which the major part of classroom instruction is received. Individual tests may be made on children, even in the preschool age, by requiring them to repeat the numbers to the examiner instead of writing them.

These tests have been conducted in a large number of school systems in the United States. In some, an endeavor is made to repeat the tests each year on all pupils. Some have efficient follow-up systems whereby educational adjustment is made and the attention of a competent otologist provided when indicated. Reports of such tests do not always appear in the journals since the information received by giving the tests largely concerns the adjustment of the child in the school system, but otologists located in the cities where such examinations are routinely given are frequently called upon to provide care for those who are found to be hard of hearing. The American Federation of Organizations for the Hard of Hearing is aiding materially in initiating and carrying on this work.

The enthusiasm with which the 4A audiometer was received and the number of studies presented indicates its popularity for preliminary tests in the public schools. Fowler[14] reported the results of tests on 1,000 children in the public schools of New York. After testing these pupils, the 7.3 per cent who were found to be defective were given more careful individual tests and the results classified. Laurer[21] in 1928 reported a survey of the hearing of 4,419 pupils in eight grade schools of Syracuse, N. Y., during the school year of 1926-27. Ten and six-tenths per cent of the boys and 12 per cent of the girls had defective hearing (indicated by a loss of nine sensation units or more), and in 5 per cent of these the loss was noted as being "severe." In 1930 Sterling and Bell[35] reported the results of the tests on 1,860 school children from the third to the ninth grade. They noted slightly more marked impairment of hearing among the boys than among the girls of all grades. Rodin[28] in 1930 reported a comprehensive study of the hearing of 36,191 children from nine to sixteen years of age in the San Francisco public schools and found that 9.5 per cent were defective. These studies are summarized by Newhart[25] as follows: "Reports received up to June 1, 1929, in response to a comprehensive questionnaire sent out by the writer showed that already several hundred thousand school children had been tested in thirty-four cities having a total population of 6,800,000. . . . An average of more than seven per cent of those tested revealed a hearing defect of such a degree as to demand a careful medical scrutiny. . . . Children in rural districts are found to have defective hearing in greater numbers than children in large cities. . . . Young children show a more frequent

incidence of impairment than the older groups. . . . The movement to ultimately secure for every school child the benefit of a periodic hearing test is making rapid growth."

Rowe and Drury[29] in 1932 reported a study of the hearing of 2,078 children selected from eighteen schools in Massachusetts; 590 gave evidence of impaired hearing. Further individual tests showed that 276 (13.3 per cent) had hearing defects sufficient to warrant report, and fifty of these gave evidence of lowered mentality. Waldman and Wade[37] found in a study of 1,079 children that 5.5 per cent had defective hearing, that 87 per cent of these had speech defects, and that children with very good hearing had higher intelligence quotients than those with poor hearing. Norris[26] in 1933 points out the necessity for special classes in lip reading and speech correction for the hard-of-hearing pupils.

It is not to be assumed that examiners in Europe have discontinued the work of the earlier investigators. Results, however, are rather difficult of comparison. Encina[10] in 1930 reported the results of tests on pupils of the primary schools of Montpellier. With the cooperation of the various interested agencies both in America and in Europe, we can hope that most of the deafness in childhood may be discovered and much of the maladjustment which comes from deafness in later life may be prevented. Many of the cited studies report that active work is being carried forward to correct, as far as possible, the physical factors which are responsible for the deafness in childhood.

Studies dealing with the hearing of pupils in schools for the deaf should be listed under this classification since these reports also deal with tests on children who are able to comply with instructions. These children are not segregated because they are totally deaf but because their handicap of deafness is so great that they are prevented from receiving instruction in the ordinary classroom. Tests on these children have an entirely different application than do those done on ordinary school children. The problem in these tests is to determine the location and extent of any residual hearing so that these remnants of hearing may be used in the education of the child.

Bezold[3] using his continuous tone series of tuning forks pointed out the frequency with which tonal gaps and islands appeared in the hearing range. He says, "Up to 1898 I tested 276 organs of deaf-mutes. Of these seventy-nine were totally deaf. The others had remnants of hearing of various extent. . . . 34.8 per cent showed such extensive remnants of hearing distributed over a large part of the sound scale that they were not different from a large number of adult hard-of-hearing people with whom everybody can converse very easily. . . . It became evident that by far the most important part of the tone series for the understanding of speech is the part between b′ to g′. . . . It is evident that these numerous and extensive remnants of hearing which are found in more than one-third of all deaf-mutes ought to be made use of for the purposes of education."

Bezold criticized Urbantschitsch's method of testing these deaf-mute children with a harmonium because of the possibility of their misinterpreting the sensations received by touch with those received by hearing. However, he gives Urbantschitsch full credit for introducing the plan of utilizing this residual hearing in their educational work. These two studies were forerunners of an almost universal

practice in modern educational institutions for the deaf. In America, the principle was fully explained by Goldstein.[17] Bunch[7] in 1919 with the advent of the audiometer stressed this point in his study of the hearing of the pupils of the Iowa School for the Deaf. Alden[1] in 1923 studied not only the cochlear but the vestibular function in forty-four children with congenital or early acquired deafness. Shambaugh et al.[31] in 1931 reported the results of a comprehensive study of this problem conducted under the auspices of the National Research Council. His statistics showed that 61.7 per cent of the children in the schools in which this survey was conducted were deaf by the third year of life, and 78 per cent had become deaf by the time they were five years of age. In August of 1930[32] the study had progressed far enough to warrant this statement: "Early childhood, up to the age of ten years is the danger period for loss of hearing." Bieri[4] says, "We are offered an opportunity to reduce to a minimum the handicap of dumbness by early extensive and intensive speech training." Parrel and Melzi[27] stress the fact that the deaf-mute child must receive his beginning pedagogic care by the age of three years or he will be mentally retarded in comparison with normal children.

The second group of reports, i.e., those relating to tests of children who are unable to respond to the instructions of the examiner, is largely concerned with reflex movements which are the reactions of the child to sound stimuli. At best, these indications are not satisfactory and are often entirely inadequate. Bower[5] writing in 1931 states, "The functional testing of hearing of children's ears is rather difficult, and in any case it cannot be considered complete until after the child is six years old or more." Goldstein[18] in 1933 says, "Functional tests of hearing in the young child, presumably deaf, are of no avail, for the responses are too indefinite and too inaccurate. Even in a child of two years of age it has been my experience that tests with various devices for the production of sound, such as bells, tuning forks, whistles, organ reeds or pipe, etc., elicit no accurate or serviceable response. Noise, such as clapping of the hands, stamping on the floor, a clap of thunder, etc., may be interpreted by the observer as hearing, when, in reality they are but tactile impressions. . . . Positive diagnosis of deafness is exceedingly difficult, especially in the first, and sometimes in the second or third year."

It is generally assumed that a child at birth is quite hard of hearing because of anatomical conditions. Gleason[15] says, "The vernix caseosa . . . also extends into the auditory canal, completely blocking it up so that no air can enter. The drum head is entirely covered by extremely thick epidermis, while the cavity of the middle ear is usually completely filled with embryonic tissue (mesenchyme). . . . Hence the offspring of the human race, like that of many lower animals, is born into the world almost completely deaf. . . . It is not until the eighth or tenth day after birth that an infant shows any evidence of hearing the sound of a tuning fork held close to its ear." Bryant[6] states that "the acuteness of normal hearing may be described as a curve which rises from zero at birth, reaches its maximum at the completion of adolescence, and gradually declines to a very low point in old age." Forbes and Forbes[11] think that even in the late fetal stage a child may be observed to react to loud sounds. Their observation is described as follows: "A pregnant woman in a bathtub be-

comes aware of the fetal movement when the side of the tub is violently struck. She herself is calm; even her skin does not move. The movement of the fetus is independent of effects from her breathing movements. Eight days after the child is born, while feeding at its mother's breast, it takes notice of a distant gong by flattening its ears against its head and by stopping feeding; after the gong has ceased the baby resumes its feeding."

Chrisman[8] quotes the observations of Darwin who noted that his child reacted to sound during the first fortnight of life. This is probably one of the earliest reports of this kind. Hetzer and Tudor-Hart[19] in 1927 report the results of experiments performed on 126 children from one day to five months of age in various institutions in Vienna. A series of noises were used as stimuli. The frequency of all positive reactions to the sounds rises rapidly during the first week from an initial value of 34 per cent to about 50 per cent, and then more slowly to about 78 per cent at the end of the second month.

Stein[34] lists three reflex signs useful in examining ears for deafness: the auricular, concerned with the motions of the external ear; the pupillary, concerned with the dilating action of the sphincter pupillae; and the cochleopalpebral, concerned with movements of the eyelids; all of these being produced by sudden loud sounds. In looking for these responses, the examiner is warned that the patient must not be aware that the stimulus is to be given. Bower[5] also mentions the latter reflex under the term "auropalpebral" and credits its inception to Bechterew.

More recently, tests using the method of conditioned reflex have been employed. Aldrich[2] with this technic tested a three-month-old baby who, in the opinion of three competent physicians, was deaf. The procedure is described as follows: "By ringing a bell while the baby's foot was scratched with a pin causing a drawing-up of the leg and crying. After from twelve to fifteen trials at half-hour intervals, the bell alone was rung, which caused the child to look worried and cry, thus giving convincing evidence that she could hear."

All of these methods are inadequate for determining qualitative and quantitative values of auditory acuity in children who cannot follow instructions. The problem is so complicated that one is justified in using any available method which gives definite information. Stein[34] says, "Every conceivable expedient must be employed to bring about an accurate statement of the subject's hearing ability." All must be used in clinical work when necessary.

The conditioned reflex methods are not often applicable to clinical work, because of the time required to condition the child and the necessity of completing the examination in one sitting. Because of previous experiences with other examiners, these children when they enter the clinic are usually frightened. The sight of a nurse or doctor in uniform or even the presence of a white examining table will recall unpleasant situations and quite often they are obstreporous. The presence of the parent or teacher is often a distinct handicap in conducting these tests. The first problem of the examiner is to secure the child's confidence. Once this is accomplished, and the child is no longer frightened, the examination can proceed as a sort of game.

Toys and playthings should be provided to attract the child's attention. Any loud sound can then be made while the child is playing with the toys, and the reactions to this stimulus be noted. He may jump and turn about to locate the sound source and in so doing give definite evidence that it is heard. Care must be taken that the motions of the examiner are not visible to the child and that the stimuli are not perceived through the sense of feeling or touch. A positive response does not indicate which ear heard the sound although, if one ear is deaf, the child may turn the hearing ear toward the source of the sound. A positive response to one tone does not indicate that he hears all nor does lack of response to one tone indicate deafness for all. Toys which produce loud sounds can often be used to secure information. The child may be given a horn for a toy and instructed how to blow it. If he continues to blow the horn, it is a sign that the action gives him pleasure which he would not obtain by simply blowing through a tube. He may be given two horns, one of which is silent. If he selects the one which functions properly, we have definite evidence that he hears this horn. Even in the home, an intelligent parent can secure information by procuring toys that make considerable noise. This may not be pleasant for the child's associates but can be tolerated because of the necessity of securing definite information. An electric bell connected to a push button located at some distance may be an adequate toy. Tests for bone conduction are useless since tactile impressions cannot be eliminated.

These tests do not give information regarding the quantitative value of hearing, nor do they, when positive reactions are obtained, differentiate the deaf ear. An audiometer producing a large number of loud tones through a telephone receiver is often an aid. If the child will permit the receiver to be held at his ear, the reactions may be noted for different tones. The intensity may be decreased until the reactions disappear. This test may be tried at each ear and a rough estimate of the qualitative and quantitative values of hearing be obtained. Many times the child will hold the receiver to his own ear and manipulate the dials as he desires and by so doing give further evidence as to the amount of residual hearing. It is scarcely necessary to say that even with the most careful examinations, the information secured will be meager, but a positive response to sound is of great value for prognosis and diagnosis. After two afternoon sessions with a boy of four years, an eminent child psychologist was unable to tell whether the child was feebleminded or deaf, but two years later the child was making rapid strides in lip reading under a competent teacher, and it was easy to see that deafness alone was the handicap.

Tests of the static labyrinth give some information concerning the condition of the eighth nerve, but it is often noted clinically that the cochlear portion of the nerve may give no response when an active response may be secured by testing the static labyrinth. Goldstein[18] says, "When nystagmus is present in a case of a very young child so tested, it has been my conclusion that some functioning capacity of the hearing nerve (acoustic) is active, even if only to a limited degree."

Perhaps the most common and useful criterion of the condition of the hearing of a young child is shown by his prompt acquisition of

spoken language. If he fails to use spoken words by the time he is two years of age, the parent and physician should strongly suspect deafness as the cause of his retardation.

REFERENCES

1. Alden, A. M.: Laryngoscope **33:** 665, 1923.
2. Aldrich, C. A.: Am. J. Dis. Child. **35:** 36, 1928.
3. Bezold and Siebenmann: Text Book of Otology (Trans. by J. Holinger), Chicago, 1907, E. H. Colgrove Co., p. 301 ff.
4. Bieri, E.: Ein Beitrag zur Kenntnis der Geistigen Entwicklung des taubstummen Schulkindes, Zurich, 1931, Lehman.
   See Psychological Abstracts, No. 727, 1933.
5. Bower, Richard L.: Wisconsin M. J. **30:** 5, 1931.
6. Bryant, W. Sohier: Ann. Otol. Rhin. & Laryng. **16:** 357, 1907.
7. Bunch, C. C.: Proc. of Am. Instr. of the Deaf, 1925.
8. Chrisman, Oscar: Pedagogical Seminary **2:** 397, 1892-93.
9. Crandall, I. B., and MacKenzie, Donald: Bell Telephone Technical Journal **1:** No. 1, July, 1922.
10. Encina, M. J.: Rev. oto-neuro-ophth. **5:** 16, 1930.
11. Forbes, H. S., and Forbes, H. B.: J. Comp. Psychol. **7:** 353, 1927.
12. Fowler, E. P., and Fletcher, Harvey: J. A. M. A. **87:** 1878, 1926.
13. Idem: Ibid. **91:** 1181, 1928.
14. Fowler, E. P.: Arch. Otolaryng. **6:** 43, 1927.
15. Gleason: Manual of Diseases of the Nose, Throat, and Ear, ed. 7, p. 454, Philadelphia, 1933, W. B. Saunders and Co.
16. Goldstein, M. A.: Laryngoscope **41:** 733, 1931.
17. Idem: Ibid. **31:** 444, 1921.
18. Goldstein, M. A.: Problems of the Deaf, 283, 284, St. Louis, 1933, Laryngoscope Co.
19. Hetzer, H., and Tudor-Hart, B. H.: Quel. u. Stud. z. Jugkd. No. 5, 103, 1927. See Psych. Abst. No. 2593, 1928.
20. Hughes, D. E.: Phil. Mag. **2:** p. 50, 1879.
21. Laurer, F. A.: Am. J. Pub. Health **18:** 1553, 1928. See Psych. Abst. No. 5096, 1930.
22. Lichtwitz, R.: See Abst. in Arch. Otol. **19:** 329, 1890.
23. MacMillan, D. P.: Medicine **8:** 265, 1902.
24. Miller, D. C.: The Science of Musical Sounds, p. 78, New York, 1916, The Macmillan Co.
25. Newhart, Horace: Canad. M. A. J. **25:** 314, 1931.
26. Norris, A. C.: J. Educ. Sociol. **6:** 323, 1933.
27. Parrel, G., and Melzi, U.: Valsalva, p. 7, 1931. See Psych. Abst. No. 2955, 1932.
28. Rodin, Frank H.: Arch. Otolaryng. **11:** 463, 1930.
29. Rowe, A. W., and Drury, D. W.: J. A. M. A. **98:** 1539, 1932.
30. Seashore, C. E.: University of Iowa Studies in Psychology **2:** 55, 1899.
31. Shambaugh, G. E., et al.: Arch. Otolaryng. **14:** 36, 1931.
32. Shambaugh, G. E.: Arch. Otolaryng. **12:** p. 190, 1930.
33. Stefanini, A.: N. Cimento 10, p. 65.
34. Stein, O. J.: Laryngoscope **29:** 657, 1919.
35. Sterling, E. B., and Bell, E.: U. S. Pub. Health Rep. **45:** 1117, 1930.
36. Urbantschitsch, V.: See Appleton's Medical Library: Diseases of the Ear, Dench, E. B., p. 145, 1909.
37. Waldman, J. L.; Wade, F. A.; and Aretz, C. W.: Hearing and the School Child, Volta Bureau. See Psych. Abst. No. 4685, 1931.
38. Weil, E.: Monatschr. f. Ohrenh. No. 12, 1880.
39. Weil, E.: Arch. Otol. p. 33, 1882.
40. Wolff, O.: See Trans. by Holden, W. A., Arch. Otol. p. 298, 1890.
41. Worsell, J. P.: Trans. Ind. State M. Soc., 1883. See Abst. in Arch. Otol. **12:** 348, 1883.
42. Yearsley, M.: Brit. J. Child. Dis. **13:** 129, 1916.
43. Zwaardemaker, H.: Ann. Otol. Rhin. & Laryng. **16:** 59, 1907.

American Academy of Pediatrics

Proceedings

FOURTH ANNUAL MEETING OF THE AMERICAN ACADEMY OF PEDIATRICS

JUNE 11 AND 12, 1934

Round Table Conference on Heart Disease

Leader: Dr. Hugh McCulloch, St. Louis. Assistant: Dr. Stanley Gibson, Chicago.

The Round Table discussion on Heart Disease, held in Room 940, Wade Park Manor Hotel, Cleveland, Ohio, convened at 9:30 A.M., June 12, Dr. Hugh McCulloch, presiding.

CHAIRMAN McCULLOCH.—It was decided to take up the subject at this meeting from the standpoint of symptoms and physical signs and treatment of heart conditions, in order to make it a part of the two conferences preceding this one. At the first conference, conducted by Dr. Morse two years ago, the general subject of rheumatic fever, its relation to heart disease, and some of the forms of heart disease common in that condition were discussed. Last year, rheumatic fever was taken up without much consideration of heart disease. In order to round out the subject a little more fully, this conference will deal with symptoms, physical signs, and treatment of congenital heart disease and rheumatic, or infectious, heart disease.

Dr. Gibson and I will discuss these two subjects separately and when we are finished, a general discussion will be in order.

DR. STANLEY GIBSON.—It requires considerable courage to undertake a discussion of congenital heart disease, inasmuch as it is a more or less obscure condition. It has been obscure partly at least because there has not been as much work done on congenital heart disease as on other forms of heart disease. There are a number of reasons for this neglect.

First, the adult cardiologist sees a relatively small number of cases of congenital heart disease, as the majority do not survive to the age where they come under his observation. Second, the pediatrician rarely is primarily, or often even secondarily, a cardiologist, and hence he is not likely to make an intensive study of these cases. Another reason why congenital heart disease has been more or less neglected is because treatment is unsatisfactory. Conditions with more therapeutic promise are naturally of more interest to the clinician.

In regard to the etiology of congenital heart disease, it is fairly well agreed that the chief cause is developmental. The cause of the error in development is unknown. One fact stands out clearly, however, and that is, the cause of the malformation in

congenital heart disease is the same as other congenital malformations. From 15 to 20 per cent of congenital cardiac patients show other congenital defects. Sometimes these defects, such as harelip, cleft palate, or deformity of the ears, are obvious on physical examination; in other instances the malformations involving internal organs are revealed only at autopsy.

A much less frequent and less important cause is fetal disease. Rheumatic infection occurring during pregnancy may be transmitted to the baby, though this occurrence is extremely rare. Myocardial disease is another cause of maldevelopment, and syphilis has been considered the most important factor in this group. Certainly, from the clinical standpoint there is no unusual association between congenital syphilis and congenital heart disease.

The symptomatology of congenital heart disease is extremely variable. We see unmistakable signs of the condition in many children who are normally developed, have a good color, and are able to play as actively as other children. On the other hand, some of these children are poorly developed, blue, breathless, and able to lead only the quietest sort of life. To account for this great variation in the clinical picture, one must have a knowledge of the nature of the defects in congenital heart disease, and the alteration in blood flow resulting from their presence.

There are three defects far more common than any others. In Maude Abbott's series of 1,000 cases, she found open foramen ovale in 290 cases, either alone or in conjunction with other defects. Next most frequent was interventricular septal defect, occurring 257 times. Open ductus arteriosus was third with 242 cases.

The above defects allow a communication between the two sides of the heart or the great vessels, that is, between the arterial and venous circulation. It is generally agreed that the pressure on the left side of the heart is higher than on the right side; hence, if any one of the above lesions exists in pure form, blood is shunted from the left to the right side of the heart. There is, therefore, no failure of aeration of the blood, in fact, a portion of the arterial blood is again returned to the lungs.

If, however, something occurring in the pulmonary circuit, pneumonia for example, causes the pressure on the right side of the heart to be raised above that on the left, a reversal of flow results, and venous blood is shunted into the arterial stream. It is this mixture of venous with arterial blood which is chiefly responsible for the presence of cyanosis in congenital heart disease.

Although open foramen ovale is the most frequent congenital lesion, it is not the most important clinically. In fact, if the opening is small, it is unrecognizable clinically, imposes no appreciable handicap, and is compatible with the usual span of life; even when the opening is large, recognition of the condition is difficult as there are usually no symptoms. Sir Thomas Lewis says he knows no direct physical signs by which it may be recognized. Maude Abbott, however, feels that in a child of slender build, who is pale, and in whom one hears a late diastolic or early systolic murmur localized at the third or fourth left interspace, the presence of defect in the auricular septum should be suspected.

In defect of the interventricular septum, the diagnosis may be made with a good degree of accuracy. The murmur is characteristic: it is harsh in quality, systolic in time, reaches the maximum in the third and fourth interspaces at the left sternal margin, and usually widely transmitted in all directions. A thrill is often present; the heart is usually little or not at all enlarged; there is no cyanosis, and the child is usually able to exercise fairly freely.

Open ductus arteriosus affords the most spectacular findings and is in typical cases the easiest of all congenital lesions to diagnose. It is characterized by a most extraordinary murmur. This murmur is usually continuous, very harsh in character,

and variously described as humming top, machinery, or rolling thunder in type; it is maximal in the first and second left interspaces and is widely transmitted. In addition to the characteristic murmur, x-ray examination may reveal widening of the cardiac shadow in the second and third left interspaces due to dilatation of the pulmonary artery which is present in these cases.

As already emphasized, the lesions described above, when existing in pure form, result in a shunting of blood from the arterial to the venous circulation, and hence do not produce cyanosis. Very often, however, these lesions are complicated by some other anomaly, particularly of the right side of the heart, which causes the pressure in the pulmonary circuit to be constantly higher than that on the left side. Under such circumstances venous blood from the right side of the heart mingles with the arterial blood, and if this admixture is large in amount, cyanosis results.

In the group of cases in which cyanosis is present, diagnosis is difficult because in the great majority of cases a combination of lesions rather than a single lesion is present. The younger the child, the more difficult the diagnosis because a great variety of lesions may produce cyanosis. It is a well-known fact, however, that not many of the combinations of lesions producing cyanosis in early life allow of long survival. One combination which does permit a longer span of life is known as the tetralogy of Fallot. It consists of pulmonary stenosis, defect in the interventricular septum, dexter position of the aorta so that the aorta overrides the defect in the septum, and hypertrophy of the right ventricle. If then one encounters a child from six to ten years of age who presents the typical picture of breathlessness, cyanosis, and clubbing of the fingers with physical signs of congenital heart disease, the condition most likely present is the tetralogy of Fallot. The physical signs are not in themselves conclusive. A systolic murmur is present over the precordium, due perhaps partly to the defect in the interventricular septum and partly to the pulmonary stenosis. The most characteristic finding is the x-ray silhouette of the heart. It has been described as the *Coeur-en-sabot*, or wooden-shoe-shaped type of heart, in which there is a broadening of the cardiac shadow, with a very blunt apex. This change of shape is due chiefly to hypertrophy of the right ventricle, which tends to envelop the smaller left ventricle.

Transposition of the great vessels and complete absence of the cardiac septa are interesting conditions in that, while they produce a high degree of cyanosis and have a very serious prognosis, murmurs over the heart may be altogether lacking.

These cases of arterial-venous and venous-arterial shunt comprise the greater proportion of cases of congenital heart disease. There is, however, a third group in which no shunt exists, but in which some anomaly of the heart or vessels may be present which results in more or less cardiac strain. From the clinical standpoint the most important condition in this group is coarctation of the aorta. Coarctation of the aorta may be either of the infantile or adult type. In the infantile type there is a diffuse narrowing of the isthmus of the aorta, and there are usually other associated anomalies in the heart which render the condition incompatible with long life. Hence this condition, rarely encountered except in infancy, cannot be diagnosed during life.

The adult type of coarctation occurs more often, is compatible with an active life, and can be diagnosed if one is on the alert for it. It consists of a sudden narrowing of the aorta in the region of the ductus arteriosus, much as if a ligature had been tied tightly around it. Because of this constriction, the blood pressure in the upper extremities is elevated, often to 200 or more. The increased pressure may cause headache, dizziness, ringing in the ears, or nosebleed.

The circulation beyond the point of coarctation must be carried on chiefly through the development of a collateral circulation. Hence there is decreased or absent pulsation in the femoral and dorsalis pedis arteries; the blood pressure in the legs is low or cannot be measured at all.

Inasmuch as the intercostal arteries must aid in carrying the collateral circulation, they are frequently so large that their throbbing can be felt, especially in the interscapular region and in the axillae. These enlarged arteries frequently produce erosions of the ribs which are demonstrable on x-ray examination and, when present, serve to clinch the diagnosis in doubtful cases.

Examination of the heart itself may show some enlargement, and a systolic murmur over the precordium with transmission toward the neck is usually present.

Coarctation of the aorta is in the majority of instances overlooked during life. The number of reported cases at autopsy, however, indicates that it is not a rare condition. If in children with high blood pressure the condition of the circulation in the lower extremities were investigated, no doubt a good many cases would be discovered. I have seen two children with this condition. One child had had a hemiplegic attack, and the blood pressure in the course of a routine examination was found to be 200. The femoral pressure was unobtainable. X-ray pictures revealed scalloping of the ribs. The second child had developed nephritis in the course of scarlet fever. Blood pressure was 180 and persisted as the nephritis improved. There was a loud systolic murmur over the precordium. In this case also the femoral pressure was unobtainable, and x-ray examination showed erosion of the ribs.

The prognosis in congenital heart disease must be determined by a variety of factors. In the infants who are cyanotic from birth, the outlook is usually grave. In those infants who have cyanotic spells or who become persistently cyanotic in the first few years, there is usually a sufficient handicap to the circulation to make the outlook bad. On the other hand, there are many children with unquestioned signs of congenital heart disease who have good color, develop normally, and are able to exercise freely. So far as the handicap to the circulation is concerned, these children could carry on indefinitely.

There is another hazard, however, with which all children with congenital cardiac anomalies must cope, and that is a complicating infection. Pneumonia, tuberculosis, or especially subacute bacterial endocarditis may cause death. Statistics reveal the surprising fact that almost 20 per cent of patients with congenital heart defects succumb to bacterial endocarditis. We, as pediatricians, are apt to forget this fact, because many do not develop bacterial endocarditis until they are beyond the pediatric age.

Largely because of the likelihood of complications, the prognosis must be guarded even in the apparently mild cases.

I should like to quote from Maude Abbott's statistics to bring to mind the seriousness of congenital heart disease. In 40 cases in which patent foramen ovale was the primary lesion, the average age at death was twenty-nine years; in uncomplicated open ductus arteriosus, twenty-four years; and in interventricular septal defect, fourteen and one-half years. Yet the above lesions are regarded as among the mildest congenital cardiac anomalies. In the tetralogy of Fallot the average duration of life was about twelve years, and in coaretation of the aorta the average was thirty-three years.

Little need be said regarding treatment. Since we do not know the cause of the condition, we cannot prevent it. We cannot by surgical methods correct the anomalous condition; therefore, the treatment is chiefly supportive. One should stress the importance of keeping these children free, so far as possible, from upper respiratory

infections or contagious disease, as they do not stand infection well. Moreover, the danger of bacterial endocarditis is always to be kept in mind, and it is more likely to occur if they contract an infection which lowers their resistance.

Where a choice is possible, a warm, sunny, equable climate is desirable.

So far as the child's activities are concerned, it is my experience that there is much less difficulty in controlling the child with the congenital than the one with the acquired cardiac disease. The child with congenital heart disease has grown up with his handicap; since he has learned from the age of beginning to walk that if he tries to do too much, he becomes fatigued; from infancy he has been accustomed to a quiet life. The rheumatic child has known what it is to romp and play and take part in games, and he does not so readily adapt himself to a more quiet existence.

In closing I should like also to mention the importance of proper mental hygiene. The cardiac child should be taught to make the necessary adjustments to enable him to lead a life that is happy and useful.

CHAIRMAN McCULLOCH.—It is very fortunate that we have been able to hear this presentation of congenital heart disease because it is not often discussed other than by case reports. From a pediatric standpoint, congenital heart disease is extremely important, and all of us see many children who require expert or adequate opinion as to their management. They form a fairly large percentage of a pediatric cardiac practice.

There are two other types of heart disease that do not concern us as pediatricians in any great degree. One is syphilitic heart disease and the other, degenerative heart disease associated with recessive growth of body tissue.

The fourth major type of heart disease is due to rheumatism and might be considered as infectious heart disease.

It has always seemed wise to me to describe infectious heart disease as "rheumatic heart disease" because by far the largest number of cardiac children have rheumatism in some form or other. According to a strict terminology, infectious heart disease would probably be more correct because in that way one could include the few cases not of a rheumatic nature but due to various subacute bacterial infections, such as *Streptococcus viridans*, pneumococcus, meningococcus, and gonococcus, and the occasional organism present in a newborn child or during infancy which produces heart disease as a part of a generalized infection. Even those cases of carditis occurring in early infancy in which rheumatic fever is either obscure or entirely absent should be included as rheumatic in nature because at autopsy one can show the process in the valves and in the muscles to be identical with rheumatic heart disease that is easily recognized in later life. Therefore, as I present the subject this morning, I have in mind the picture of rheumatism and rheumatic heart disease.

Changes in the heart and other parts of the body in rheumatic heart disease consist of two different processes: First, the exudative manifestations of rheumatic fever, characterized by changes in the wandering or labile elements of the body tissue—for instance, edema, vascular injury, capillary dilatation, the laying down of fibrin, the infiltration of polynuclear leucocytes, local heat and so forth. Second, the proliferative manifestations, characterized by changes in the fixed tissue elements of the body, such as overgrowth of epithelioid cells, infiltration of the plasma and round cells, and the formation of scar tissue.

In the heart the first process manifests itself by first a myocardial injury consisting of edema, cloudy swelling, fatty infiltration, leucocyte infiltration and in severe cases, a certain degree of necrosis of the cardiac muscle cells; and, second, a valvulitis characterized by the same changes that occur in the acutely inflamed

joint—edema, capillary injury, and cellular infiltration of the valve, resulting in thickening and loss of elasticity; and third, an acute or subacute serofibrinous pericarditis.

In the second process there is an acute, subacute, or chronic change producing, first, myocarditis with Aschoff's nodules comparable to the rheumatic nodules found elsewhere in the body, a myocarditis existing over a longer period of time and resulting in a chronic fibrosing interstitial lesion; second, chronic fibrotic scars in the valves preceded by, or associated with, rheumatic verruca on the valves; and third, an obliterating pericarditis.

It is easy to describe these two processes theoretically as being separate and distinct. We know, however, that many times these two processes are present in the same child, and each of them may be recognized.

I am going to describe the individual lesions in rheumatic heart disease in as controversial a manner as possible with the idea of provoking discussion later on. Pericarditis may be extensive, with the whole pericardium involved, or localized in patches, and it is rarely suppurative in younger children. The fluid in acute serofibrinous pericarditis rarely persists; while the clinical picture may be extremely serious and it is common to find the hospital internes despairing of the patient's life, the condition is rarely fatal under proper care.

The clinical picture of acute serofibrinous pericarditis bears a very strong resemblance to that of acute lobar pneumonia, and many times in the early stages it is diagnosed as acute lobar pneumonia. The course of the attack also resembles in many varied details an acute lobar pneumonia. It is worthy of note, too, that in many instances the lesion in the pericardium improves as satisfactorily and as completely as the infiltration in the lung in pneumonia.

Acute serofibrinous pericarditis should be suspected whenever there are spells of fever occurring in a rheumatic child without other obvious causes, especially if there is no acute infection in the nose and throat. At times attacks of fever may occur in the rheumatic child without pericarditis, but this condition should always be suspected whenever the temperature rises.

When the rheumatic child complains of pain in the chest during a period of fever, serofibrinous pericarditis should be suspected. Usually the friction rub can be heard, but in some instances the lesion may be in some part of the pericardium where the friction rub is not audible.

The diagnosis of chronic adhesive pericarditis is rarely made during life because these children have very few symptoms and the physical signs are not recognized or may be absent. It should be suspected in those children who have chronic heart disease with marked precordial deformity and pulsation, especially when there is congestive failure out of proportion to the degree of injury to the myocardium and when all of the usual remedies for the relief of congestive failure fail. Young children with thin, elastic chest walls do not show the same fixation of the heart that older children and adults do. It has also been our observation that Broadbent's sign is not a very satisfactory physical sign for the detection of chronic adhesive pericarditis because the chest wall and mediastinal tissues are so very elastic that the tug of the heartbeat is not against a semirigid or fixed structure and also because the lesion is rarely confined to the diaphragm.

Pericarditis of one form or another occurs more frequently than is usually recognized in children with rheumatic fever. The acute forms are associated with fever, pain in the chest, cough, and prostration. The principal physical sign is a pericardial friction rub sometimes not heard for several days after the onset of fever; it may be present only for a day or so because the fluid accumulates rapidly and tends to separate the layers of the pericardium causing the disappearance of the

rub. The friction rub is best and most often heard close to the sternal border as a high-pitched, superficial to-and-fro scratching sound; occasionally, it may be felt rather faintly in this same area.

Myocarditis in rheumatic fever is by far the most important lesion in the heart, and I would like to place particular emphasis on it in this discussion. It is most important because it occurs to some degree in every child with rheumatic heart disease and in every attack, whether of the cyclic exudative or of the continuous proliferative type of rheumatic fever, and because the alternate function of the heart and circulation depends largely on the nature and severity of this lesion.

The principal result of myocarditis is an enlargement of the heart from thickening of the walls, with or without hypertrophy of the cells and weakening of the muscle tone, resulting in dilatation of the chambers with increasing failure. The enlargement of the heart may be very slight and in most cardiac children amounts to no more than 1 or 2 centimeters' increase in size above the normal as measured on the chest wall or by x-ray cardiac silhouette, but the determination of any degree of enlargement is of greatest significance and importance. The absence of cardiac enlargement renders of little value all other physical signs, including the famous systolic apical murmur. Cardiac enlargement and myocarditis are associated with two other important physical signs, tachycardia and increased force of cardiac contraction revealed by palpating the cardiac impulse on the chest wall when the child is at rest or lying supine. The increased force of the cardiac impulse may be localized to the apex area but is usually widespread over the whole precordium. In severe forms of myocarditis the great loss of muscle tone and filling of the chambers result in a high systemic and pulmonary venous pressure and greater or less degree of congestive failure in one or both circulatory systems. Occasionally disturbances of mechanism may occur as a result of myocardial changes when they are present, and they may be accepted as evidence of myocarditis. The common disturbances are: auricular fibrillation, auricular and ventricular extrasystoles (premature contractions) and heart-block. These lesions occur very infrequently, however, in children. It may be possible to determine some degree of delay in cardiac auriculoventricular conduction in severe cases, but in the usual cardiac child there is no delay and no disturbances of mechanism.

An important symptom of acute myocarditis is vomiting. I would like to emphasize this symptom. It occurs frequently during an acute toxic myocarditis from diphtheria, scarlet fever, as well as during the attacks of an acute myocarditis from rheumatic fever. Vomiting is important because it is the result of the myocarditis and is not due to indigestion, distention, or overdosing with various drugs which are supposed to irritate the gastric mucous membrane, notably digitalis. It is the common reason for discontinuing digitalis in the treatment of a cardiac child, whereas many times the vomiting is due to acute myocarditis present as a part of the rheumatic fever.

It is vitally important to the patient, as far as his immediate care and ultimate prognosis are concerned, to know how well the heart can function under the existing circumstances; that is, whether the heart can mechanically force the blood through the peripheral circulation to meet the degree of activity required of the patient. In children there is rarely any factor to interfere with this circulation through the peripheral vessels except the efficiency of the pump itself and the condition of the myocardium.

In the presence of signs of congestive failure, the child's activity must be reduced to a point where the signs and symptoms of cardiac distress disappear, either by providing physical and mental rest or by the use and aid of various drugs. It should be pointed out that congestive cardiac failure occurs in children as a

late event in the course of rheumatic heart disease, in either the acute or chronic form of the disease, and that when it occurs, either very extensive or severe injuries in the myocardium have also occurred. The early signs of congestive failure, such as breathlessness, edema, and venous filling, therefore, do not occur so frequently in children and then only late in the course of heart disease. The degree of breathlessness, edema, and venous filling may be noted, but it is more important to know the amount of effort required to produce these conditions.

Breathlessness may be recognized either as a subjective symptom or by measuring the vital capacity of the respiration.

Edema may be estimated by noting the location and degree of pitting in the superficial dependent parts of the body.

Venous filling may be measured by noting the level of inclination of the body required to fill the neck veins; by measuring the venous pressure in the peripheral veins, especially those of the forearm by means of the Moritz cannula or one of its modifications; or by an air tambour and by noting the level at which the veins empty, fill, and pulsate in relation to the level of the right auricle.

Myocarditis in young children with rheumatic heart disease usually involves all parts of the myocardium, both auricles and ventricles, and the right and left sides of the heart. For this reason, signs of distress from the right side of the heart, which account for the increased force of the cardiac impulse on the chest wall, are present in an unusual degree as a result of the myocarditis.

There is a high incidence of mitral stenosis in rheumatic heart disease in early life so that the additional strain on the right side of the heart because of increased pulmonary pressure present in mitral stenosis increases the frequency of peripheral venous congestion in children.

The arrest of the inflammatory process in the myocardium determines the future of the patient's welfare and if the attacks of rheumatic infection subside and further injury ceases; if the present injury is repaired without the formation of too much scar tissue; and if too much cardiac muscle tissue is not destroyed over a period of time, recovery takes place, cardiac function is restored to normal or nearly normal limits, and the child, as the saying goes, outgrows the heart trouble.

It is important to emphasize, therefore, the part the myocardial lesion plays in rheumatic heart disease. To summarize this rather briefly, in cardiac children the usual signs of myocarditis and activity of cardiac muscle infection are three: first, tachycardia; second, enlargement of the heart; and third, increased force of the cardiac impulse on the chest wall.

The later signs of myocarditis and loss of cardiac muscle tone are those associated with congestive failure: breathlessness, edema, and increased venous filling.

Endocarditis is purposely brought up for discussion last because there is so little opportunity for controversial discussion on this point. Endocarditis occurs either on the valve cusps or on the mural endocardium most frequently of the left auricle, rarely in the right ventricle or the right auricle. The mitral valve is most frequently involved; next in order are the aortic, the tricuspid, and the pulmonary valves.

The pulmonary valve is most frequently involved in the unusual forms of subacute bacterial endocarditis due to such organisms as staphylococci, meningococci, and pneumococci. The endocarditis due to *Streptococcus viridans* usually occurs on the seat of an old rheumatic or a congenital malformation, and, therefore, the mitral valve is more frequently involved.

The lesion in these various valves should be termed "valvulitis" rather than "endocarditis," both to distinguish it from the mural endocarditis and because the lesion in the valve is not confined to the endocardium alone but really involves the

structures underneath the endocardium as well as the endothelial layer itself. The lesion in the mitral valve may or may not be associated with stenosis and this important condition should be indicated. In either the exudative or the proliferative type of rheumatic process, there is thickening, increased vascularization, and cellular infiltration in whatever valve is involved. In the proliferative lesion there are verrucae along the line of closure which resemble in every respect rheumatic nodules. During life it is not possible always to differentiate the type of lesion occurring in the valve because the physical signs are the same in each instance. Those physical signs usually are a systolic murmur heard near the apex of the heart and occasionally along the sternal border toward the base. There is also some change in the quality of the first sound at the apex, principally a lengthening of the sound together with some lowering of its pitch. It is usually louder than normal. In more advanced cases of mitral valvulitis, a presystolic thrill can be felt at the apex. The apex impulse is very forceful and can be described as thrusting. The difficulty in diagnosing these valvular lesions during life is in differentiating those with true structural stenosis of the valve from those with a functional but transient stenosis.

At autopsy I have noted that those valves with changes corresponding to the exudative lesions in the rest of the body are thickened and inelastic and must, to some extent, interfere with the column of blood as it passes through the valve orifice. Such patients during life give the same physical signs as occur in individuals with actual anatomic narrowing of the valve leaflet due to fibrous tissue infiltration of the proliferative type. In the first instance, however, the lesion is a transient one which may and often does disappear, whereas, the latter type, the changes being permanent and due to the formation of scar tissue, is often progressive.

Aortic valvulitis is common, occurring in a very large proportion of rheumatic children with organic heart disease. This lesion is very frequently overlooked because its physical signs are inconspicuous compared with those associated with mitral stenosis. Since a patient with mitral stenosis, if he has congestive failure, will also have murmurs along the sternal border resembling aortic insufficiency, the presence of the latter lesion is often overlooked. Aortic insufficiency can be recognized more easily by studying the conditions in the peripheral circulation than from any direct examination of the heart. The high pulse pressure, the low diastolic pressure, and the pulse changes in the peripheral vessels indicate when this lesion is present. Another important point is that the diastolic murmur in aortic insufficiency may be absent or very faint during the first few days after admission to the hospital, when the patient has a fast rate and is decompensated. As the patient improves, the diastolic murmur appears along the sternal border.

The other valve lesions have no common interest since they are rarely seen in ordinary cardiac practice.

The various measures for the treatment of cardiac children could be divided into three major groups: first, measures directed toward controlling the recurring infection; second, those directed toward improving the general nutrition and hygiene, both mental and physical; and third, those directed toward the care of the heart itself.

Measures directed toward controlling recurring infection are the same as those used in any group of children that we, as pediatricians, are working with and for. The question to be settled in nearly every instance, is whether or not the tonsils should be removed. Most of us are agreed that tonsils should be removed in those children who have a history of attacks of tonsillitis or who show physical signs of active or recurring tonsillitis. The commonest and most important problem, however, is that most children, even after satisfactory tonsillectomy, continue to have many recurring and severe respiratory infections. With the tonsil question settled, either by their removal or by being allowed to remain, the care of that child has

just begun because so often there is extensive infection elsewhere in the nose and throat; unless this is cared for and controlled, no benefit will result from tonsillectomy.

Rheumatic children are often in contact with members of the family and other individuals who have acute infections or who are carriers, and it is most important to break off these contacts as much as possible.

Measures for improving the general nutrition are also very important. Proper balance of food elements and the provision of vitamins related to nutrition and resistance to infection play an important rôle in the recovery of cardiac children.

Besides food, such factors as sunlight, outdoor activity, the child's daily routine, the amount of ventilation in the sleeping room, what he does in school, the contacts he makes with friends, and the amount of noise and mental confusion should be investigated and controlled for these children. These things are particularly important for those children who probably will live under the handicap of a physical restriction. The detailed regulation of the daily routine in these children should be planned and enforced. Many cardiac children are being transported to warmer climates, apparently with great success in the control of their rheumatic fever.

There is only a little to be said about measures toward the control of the disease in the heart itself, and there is very little that can be done. Salicylates are of no benefit in heart disease except in so far as they relieve the symptoms of acute rheumatic fever. In order to control the symptoms indicating a myocardial lesion such as tachycardia, cardiac enlargement, and the increased force of the beat on the chest wall, these children should be put at rest until their basal cardiac rate is slow; we have arbitrarily chosen 100 pulse beats per minute as the upper limit which they must not exceed. The pulse rate should return rather promptly to this resting level following exercise. Patients should be kept at rest until the cardiac size is decreasing, or has reached normal limits, or is stationary. So long as the heart changes or seems to be increasing in size, one must assume that there is an active myocardial lesion and absolute rest should be continued. The cardiac impulse should be quiet particularly when the patients are at rest. During periods of congestive failure, absolute rest is always indicated, and it is at this time that various drugs may be of help.

Such drugs as digitalis, those belonging to the xanthine group, of which there are a considerable number, metrazol, and many other preparations can be used for the relief of edema, venous filling, and restoration of cardiac muscle function.

Many other details in the treatment of congestive failure vary with the individual physician, and he learns which ones are best suited for the particular case.

I am particularly anxious to emphasize one principle in managing cardiac cases. We should cease trying to restrict cardiac children as much as possible, but instead we should try to keep their activity up to as high a level as is consistent with adequate protection of their cardiac function. The mistake is so often made of putting a child to bed, keeping him quiet, and placing too much emphasis on the presence of a systolic murmur at the apex instead of bringing him up as close as possible to his cardiac function by trying to build him up and adjusting him to a normal way of living.

DISCUSSION

DR. WILLIAM B. McILWAINE (PETERSBURG, VA.).—Is there any definite proof that streptococcus infection causes rheumatism? Would it be possible to find a locality where streptococcus infections do not exist and see whether or not children there have rheumatism? Could these attacks of rheumatic fever be due to allergy? Is allergy in connection with rheumatism being studied?

I have a little girl with infection in the postnasal space who, after eating crabs, had an acute attack of rheumatism with swelling in her ankles, knees, and wrist joints. The diagnosis of acute rheumatic fever was made by a cardiologist. Afterward she was proved to be allergic.

Could a definite diagnosis be made between functional and organic cardiac murmurs? I think if we can learn at this meeting how to determine whether a distinct systolic murmur in five- or six-year children is functional or whether it is organic, this group would have achieved something outstanding.

DR. HERMAN SCHWARZ (NEW YORK CITY).—I want to take issue about the distinction between cardiologists and pediatricians. I think a pediatrician should know more about heart disease in children than a cardiologist, but, unfortunately, many times he does not.

I have been very much interested in a study of rheumatism and in collaboration with Dr. Louis Gross and others have tried to reproduce it in the animal. Needless to say, we have been unsuccessful, and to my knowledge it has as yet not been accomplished. I have had an opportunity to study so-called "acquired" congenital heart disease in the fetuses of pregnant women who have had active rheumatic heart disease during their pregnancy, noting what effect, if any, the mother's condition had on the fetal heart. Poynton, years ago, had one such case, and about a year ago I saw an infant who died at birth and who had a distinct valvulitis on histologic examination.

That brings up the question of acquired heart disease in infants. I feel that in infancy we have more rheumatism than we suspect. The earliest proved case I have seen was in a seventeen-month-old baby in whom the disease had never been suspected during life. The infant had remarkable rheumatic nodules (Aschoff bodies) throughout the entire heart muscle and on the valves.

The important point is whether or not cardiac disease in a given patient is progressive. When I am asked by mothers about their children's cardiac murmurs, I often cannot be certain whether there is a definite valvulitis, though I can usually state that for all intents and purposes these murmurs do not mean progressive heart disease and that they do not call for a curtailment of the child's activities. I think that so-called functional cardiac murmurs are most often due to some mild but nonprogressive organic involvement. It is important to make a diagnosis of progressive heart disease.

In the days before the introduction of the von Pirquet test, more tuberculosis was found at autopsy than was clinically suspected; so the story now goes for rheumatism. If there were a test for rheumatism similar to the von Pirquet test for tuberculosis, we would be surprised as to the frequency of rheumatic fever in early life. You cannot diagnose rheumatism in infancy or early childhood without the presence of either rheumatic nodules or organic heart disease. Last year at the Mount Sinai Hospital, in the postmortem examination of six hundred hearts, definite evidence of rheumatism was found in about 10 per cent of the patients in whom there had been no clinical symptoms of the disease. I believe that every case of rheumatism or chorea is associated with some cardiac involvement. I have followed about seventy-five cases of chorea from five to fifteen years; fourteen of these I have watched for fifteen years; about thirteen, for twelve years; and there are nine that now have a ten-year follow-up. In that period every one of these patients has had some definite evidence to point toward an organic cardiac involvement, as indicated by either x-ray examination, the electrocardiogram, or a definite murmur.

One of the most important therapeutic measures is the prevention of upper respiratory infection, which certainly seems to reactivate a rheumatic condition. It is most important, too, to prevent scarlet fever in a rheumatic patient. The question

of giving salicylates has never seemed very important to me; they tend to stop pain and lower temperature but certainly do not help the rheumatism. Equally unimportant to me is the question of tonsillectomy. One sees innumerable cases which have started long after the tonsils have been removed; once clinical manifestations of rheumatism have occurred, it usually makes little difference whether the tonsils are removed or not; in fact, tonsillectomy may at times be a sufficient reason to reactivate a quiescent infection.

CHAIRMAN McCULLOCH.—Those questions are all difficult to answer. A great deal is being done in various cardiac centers at the present time to determine whether or not allergy is the nature of rheumatic fever. We will not go into a discussion of this point too much; we want to confine this conference principally to the heart and heart disease rather than to rheumatic fever.

Dr. Schwarz has answered your question about functional murmurs. I think myself that a child who has a systolic murmur at the apex probably has had rheumatism or has it at that time. The answer in each case can be found by determining whether or not any of the other signs are present. If the child has tachycardia, cardiac enlargement, or an increased force to the cardiac beat with or without a systolic murmur, he has, surely, rheumatic heart disease. If there is a systolic murmur without those three conditions, the chances are that no matter what the murmur sounds like, the child does not have heart disease. I think it would be best to disregard systolic murmurs and pay more attention to other cardiac signs.

DR. STANLEY NICHOLS (Asbury Park, N. J.).—Are there any statistics on the mortality of cases of idiopathic hypertrophy in congenital cardiac patients available? Are children with congenital heart disease who are operated on for recurrent tonsillitis and such things prone to develop a bacterial infection later?

Dr. Maliner, who does the research work in our postgraduate Children's Heart Clinic in New York, might present some results on a study carried on this winter, in an effort to prevent a bacterial endocarditis in not only congenital cardiac patients but in other patients likely to develop bacterial endocarditis.

I am interested in the points for the diagnosis of myocarditis. Acute myocarditis is rarely reported in New York. I would like to know the actual experience in rheumatic patients when they are moved to Florida and other southern states. Do they do better? I would also like to know what digitalis can be expected to do in cases of congenital heart disease with heart failure.

DR. M. M. MALINER (Brooklyn, N. Y.).—I have seen several cases of aortic stenosis of the congenital type, described by Maude Abbott as "subaortic stenosis." The characteristics of acquired aortic stenosis are present, namely, a systolic thrill and murmur in the second right intercostal space. We have never had a case diagnosed aortic coarctation in the clinic of the New York Postgraduate Hospital.

Recently the New York Heart Association published a book, *Criteria for the Classification and Diagnosis of Heart Disease.*

The diagnosis of an organic valvular lesion rests on two important signs, namely, hypertrophy of the heart and a characteristic murmur. If a case presents a typical murmur but no apparent enlargement of the heart, the lesion should be classified as functional rather than organic heart disease.

One must not be misled by a short, soft, systolic sound frequently heard over the precordium, which is merely the resonance of the booming first heart sound. If one must strain the ears to hear a murmur, ignore it, while a persistent, loud murmur over the apex, with or without concomitant demonstrable cardiac hypertrophy, means organic heart disease.

Several years ago, I used epinephrine as a means of testing these questionable heart cases. A small subcutaneous injection of from 5 to 10 minims of epinephrine (1-1,000 solution) served to accentuate the organic murmurs.

Unfortunately, however, it is rather difficult for the average physician to ascertain slight degrees of hypertrophy of the heart, even with the aid of x-ray pictures. The usual 6-foot x-ray plate is of little value; direct fluoroscopy is the best method to observe the size and position of the heart.

Dr. Nichols asked about the prophylaxis of recurring rheumatic states and the prevention of subacute bacterial endocarditis in children with heart disease. We have isolated and cultured a *Streptococcus viridans* obtained from the blood of several children with subacute bacterial endocarditis complicating chronic rheumatic valvular heart disease. The filtrate of this broth culture with the addition of bacteriophage was used for intravenous injection in a group of twelve children with a possible congenital, or rheumatic heart disease. This filtrate, when used intravenously, prevents the so-called upper respiratory infections.

We had hoped that if we could stimulate a resistance to these infections and bring about an immunity to subacute bacterial endocarditis, which kills most of the cardiac patients, we would accomplish a great deal.

I will hastily summarize the group of children treated. Each child received a total of fifty-four injections of progressively increasing amounts of filtrate at biweekly intervals. The results did not meet our hopeful expectations. During the period of treatment, the majority of children developed their customary upper respiratory infections. One contracted chorea. Another developed acute rheumatic fever complicated by pancarditis terminating in death. Still another became decompensated and died. None of the patients had a positive blood culture at any time. So in general, the rheumatic manifestations were not prevented by the filtrate. Whether an immunity to subacute bacterial endocarditis has been established in these children, time alone will tell.

In discussing the results, we are of the opinion that perhaps rheumatic conditions are not so much due to a streptococcic organism as we are at present inclined to believe.

DR. MAURICE T. BRIGGS (LYNN, MASS.).—No one has said very much about nosebleeds or joint pains. If cardiac children have nosebleeds or joint pains, it is wise to have bed rest for a more or less indeterminate period even though there is no fever or the heart does not at the time show any definite involvement.

In regard to the prognosis of heart disease, we have followed the congenital cases for a long period. There were about twenty-five in the series that were found still alive after fifteen and twenty years. Some of them had apparently outgrown the disease entirely. They had all been examined by x-ray originally and also when they were checked after the lapse of fifteen or twenty years. It was concluded that when no enlargement is revealed by x-ray examination and there is no cyanosis, the prognosis of congenital heart disease is fairly good.

One patient was a tennis champion who played for the Massachusetts state championship. He had been definitely diagnosed originally as having congenital cardiac disease. One, a truck driver, had had an original diagnosis of congenital heart disease and was found later to be not only driving a truck but also taking care of the heavy lifting and work necessary with such a strenuous job.

In regard to the prognosis of infectious heart disease, I studied this year eighty patients who had been in our clinic. In this group who had had infectious heart disease over five years, many showed quite a surprising improvement.

Last winter I had a case of fetal endomyocarditis. I found there had been four cases at the Boston Children's Hospital and reports of fourteen in the literature.

DR. GIBSON.—I did not say much in my discussion about murmurs and their differentiation. When a child has a heart murmur, the parent immediately asks whether it is serious, and we must do our best to give a correct opinion.

In most instances one can differentiate between organic and functional murmurs. Organic murmurs in children are due either to congenital or rheumatic heart disease. If one keeps in mind the location and the nature of the lesions of congenital heart disease, he will appreciate that practically all the murmurs, except those of open ductus arteriosus, are systolic in time and have their maximum intensity above the apex.

In rheumatic heart disease the mitral and aortic valves are most frequently involved. Mitral involvement gives a systolic murmur maximum at the apex, transmitted to the left. Sometimes, of course, there is also a mitral diastolic murmur at the apex. Aortic involvement, in children at least, produces a basal diastolic murmur due to the presence of valve insufficiency. In general, it may be said that an organic systolic murmur at the apex or a diastolic murmur at the base is suggestive of rheumatic heart disease, while an organic murmur, systolic in time and maximum at the base, suggests congenital heart disease.

In differentiating functional from organic murmurs, one must consider the history of the case, also the location and quality of the murmurs. Functional murmurs are seldom maximum at the apex but are usually heard best in the second left interspace, sometimes in the third or fourth left interspace. They are practically always systolic in time. They are usually softer than organic murmurs and are seldom widely transmitted. They change very appreciably upon change of position, or upon change of heart rate. They may be quite loud at one examination and scarcely audible at a subsequent one. Oftentimes they disappear at about the age of puberty. Absence of cardiac enlargement or other evidence of heart disease is also an important point in differentiation.

In regard to the questions about congenital idiopathic hypertrophy, the diagnosis is not often made except at autopsy. As far as I know, the prognosis is always very bad. Of course, the name "congenital idiopathic hypertrophy" is a confession of our ignorance of the condition. It has been recently shown, however, that glycogen storage in the heart muscle is the essential pathology in a considerable number of these cases.

Concerning operations on children with congenital heart disease, I feel that operation may be undertaken safely except in the highly cyanotic cases. In fact, Maude Abbott emphasizes the importance of removal of tonsils and adenoids, or other foci of infection, when indicated, with the idea of lessening the danger of a bacterial endocarditis.

It seems to me that when congestive failure occurs in the course of congenital heart disease, digitalis would be indicated just as it is in other forms of heart disease.

I was much interested in the statement about outgrowing congenital heart disease. I can conceive that the foramen ovale or ductus arteriosus might be late in closing, and so in early infancy yield a murmur which would disappear later. It is quite true that we sometimes see cases of undoubted congenital heart disease in which the murmur is very faint, or at times absent altogether, but I would be somewhat hesitant in saying that the child has outgrown the condition.

DR. PHILIP ROSENBLUM (CHICAGO).—If we hear a murmur in a patient who has no previous history of heart disease, no real cardiac enlargement, or disability, I see no reason for getting excited about it. It is often a question that can only be answered by observing the patient over a long period of time.

I was happy to hear Dr. McCulloch's remarks about myocarditis because just recently I saw brought into the clinic for general examination a child, who was quite breathless; no one could fit this breathlessness into the picture. The child had endocarditis and also real myocarditis. The breathlessness was, no doubt, due to that. We do not make the diagnosis of myocarditis nearly as often as it is present.

Adhesive pericarditis has always been a problem in diagnosis. The diagnosis is not made as often as it is found at autopsy. We will have to make the diagnosis earlier in order to take advantage of any operative procedure such as cardiolysis. It seems to prolong life a little, though it will take some experience to say which patients should be operated upon and when.

So far as the pulse rate is concerned, Dr. Wiggers, of Cleveland, has shown that in aortic insufficiency, a slightly rapid pulse rate is compensatory; we must take this into consideration when we are taking the pulse rate.

After digitalis is given to children with decompensated hearts without any effect, we have stopped it, especially where there is marked edema or generalized anasarca. Instead, we put them to bed and give ammonium chloride and after twenty-four or forty-eight hours, we give salyrgan. After the salyrgan has had its effect, we then begin digitalis. We previously wondered why sudden death sometimes occurred in these patients when large doses of digitalis were given early. The digitalis was excreted into the fluids and was concentrated there so that when salyrgan was given the digitalis was taken up into the blood stream and poisoning resulted. A small dose of morphine repeated will ofted do as much as digitalis in the beginning, and it makes the patient more comfortable. I think if this is kept in mind the results will be more satisfactory.

DR. MARGARET NICHOLSON (WASHINGTON, D. C.).—In the capillary bed of the cyanosed clubbed finger tips of the congenital cardiac patients, there is an increase in number and size and a change in shape of the capillaries. When the cyanosis disappears, does the capillary bed return to normal?

DR. W. AMBROSE McGEE (RICHMOND, VA.).—When a child develops a systolic murmur at the apex and has an unexplained fever of one-half to one degree, I feel the safest thing to do is to put the child to bed until the fever subsides. While the child may have a normal apex impulse and no cardiac enlargement (as shown by the x-ray examination) and not a very rapid pulse rate and when all such reasonable tests, as tuberculin skin test, are negative, and there are no apparent foci of infection, it seems advisable to class him as a potential rheumatic patient. By keeping him in bed, the only damage done is that particular child might miss some pleasures of life and time from school; but he might be very materially damaged if he is allowed to remain up when running an undetermined fever.

In attempting to separate the functional from the organic murmurs, I feel that if the Schilling differential blood count comes within the normal range, that test would show there was probably an absence of infection or tissue derangement. As rheumatic patients improve, or those children who have unexplained fevers improve, the shift to the left in the Schilling differential count decreases, but it does not usually return to normal for a long time.

The ordinary differential blood count (Ehrlich) will frequently appear normal when the Schilling differential blood count is far from normal.

CHAIRMAN McCULLOCH.—Dr. Patton, now at the Rockefeller Institute, has studied the time of closure of the various fetal cardiac foramina after birth. It is generally believed that these openings, such as the foramen ovale, close rather quickly

after birth, as soon as postnatal circulation is established. He was able to show in various anatomic studies that the closure takes place much later than that. The foramen ovale, for example, closes completely and permanently somewhere between the fourth and sixth months of postnatal life.

I have seen several infants who had present at birth rather loud murmurs which I thought were due to a patent foramen ovale. When the children reached the age of six months to one year, those murmurs were lost. Whether or not one could call that outgrowing congenital heart disease, I do not know; but so far as the murmur is concerned, it would be called outgrowing it.

DR. GIBSON.—I should like to ask Dr. McCulloch a number of questions:

In the absence of a friction rub how is one going to tell whether the symptoms are due to myocardial involvement alone, or to a combination of myocarditis and pericarditis?

In what percentage of cases of active rheumatic heart disease do you find electrocardiographic changes?

Do you believe in the use of digitalis in the presence of active cardiac infection?

How often do you find peripheral signs of aortic insufficiency in the absence of the aortic diastolic murmur?

What do you think of the value of the sedimentation rate in determining when a child is convalescent?

CHAIRMAN McCULLOCH.—Epistaxis is a very important sign of rheumatic fever and heart disease. All children who have epistaxis do not have rheumatic heart disease; but when they do have rheumatic heart disease, it is a very common symptom, particularly in those individuals who have rheumatic nodules and proliferative rheumatic changes. I do not know what might be the cause of this epistaxis.

Our children have been examined repeatedly, and in most instances a small ulcer has been found on the septum. However, there must be more than that to cause epistaxis in this disease with such regularity. It may be a sign of the capillary injury that occurs in rheumatic fever, and the injury to the vessels in the nasal mucosa may allow blood to escape. I believe it is not generally recognized among pediatricians as one of the causes of epistaxis.

Every patient with pericarditis, particularly of the chronic adhesive type, has more or less myocarditis as well. It may be quite difficult to decide whether the myocardial failure or the pericarditis is responsible for the congestion and edema. After various measures for the control of congestive failure have been tried without effect, there comes a time when you feel that such a patient has more than just ordinary cardiac failure. This is particularly true in children in whom congestive failure is rather rare. Those patients who show considerable enlargement of the liver out of proportion to edema elsewhere in the body and who show precordial deformity with marked precordial pulsation suggest very strongly the diagnosis of chronic adhesive pericarditis. It is difficult to distinguish between the failure resulting from myocarditis as contrasted to that resulting from the adhesions in the pericardium.

I am not able to answer the second question. We have made a large number of electrocardiograms of rheumatic patients. It is difficult to recognize important changes. During the very active stages of myocarditis electrocardiographic changes occur, especially prolongation of the A-V conduction time. Other than that, the other changes are very slight or very infrequent.

Two things which I felt were on the horizon have come up for discussion today. One is the diagnosis of systolic murmurs at the apex; the other, the use of digitalis in the treatment of cardiac disease. Those subjects would require a morning for discussion.

I have always felt, as Dr. Rosenblum states, that there are many things that can be used in cardiac children suffering from infection before digitalis is tried. From the studies I have carried on, I believe patients are frequently not benefited by the use of digitalis and occasionally are definitely injured by it.

Dr. Schwarz said that most of the patients are suffering from actual infection in the heart muscle, and during that time digitalis may do as much harm as good. These patients should be put to bed first, given complete rest, the diet attended to, theocalcin, ammonium chloride and salyrgan, and other remedies, and then digitalis given later, if the others fail.

We, too, have had such a case as Dr. Rosenblum described. The patient, with moderate edema, was given a lot of digitalis, and after about five days complete heart-block developed suddenly. The drug was discontinued and the block disappeared within about forty-eight hours. Salyrgan was tried, in just the reverse order from his description, with a very prompt diuresis. The patient was greatly improved in about twenty-four hours, whereas, the digitalis had caused a great deal of harm.

In regard to the peripheral signs of aortic insufficiency, I disagree with Dr. Gibson. I think they are present very early and in considerable degree in most cases of aortic insufficiency. When the patient is admitted to the hospital with a moderate degree of congestive failure (and most of them have mitral stenosis), it is very easy to overlook the diastolic murmur along the sternal border, whereas, under those same conditions the peripheral vascular signs are very easy to recognize. The blood pressure must be taken and the peripheral pulse noted in all cases of congestive failure even though the diastolic murmur is not heard. A good many of these patients show the diastolic murmur several days later as they begin to improve. One explanation may be that the heart sounds are simpler, the closer study helps to analyze the various murmurs present, and that the ear can appreciate the diastolic murmur along the sternal border; but it is a very common observation that these patients with aortic insufficiency are not diagnosed in the first few days of admission to the hospital. If one is familiar with the size of aortic insufficiency in heart disease, the lesion will usually be recognized. I would like to emphasize, therefore, the value of these peripheral vascular signs.

A pulse rate of 100 is an arbitrary level at which one can decide whether the patient has an active infection, but there are many notable exceptions to that rule. There are many individual variations in pulse rate. Some patients with a very acute myocarditis may have a bradycardia of 80-70 beats and a normal mechanism. In ambulatory cardiac children, it has proved an extremely useful guide and can be used in the same way as the body temperature reading.

I would hesitate to keep in bed a child who has no more than 0.4° of fever. We have applied a rule in our cardiac clinic that the patient with an active infection must consistently show a temperature as high as 100° F. or more or must show a daily variation of at least 1.5° between the lowest point and the highest point in the period of observation, which is usually one week; in other words, 99.4° or 99° above the normal of 98.6° would hardly be described as fever. For guidance in managing ambulatory cardiac patients, especially when an active rheumatic fever is suspected, these two signs are extremely useful.

The sedimentation rate of blood cells is being used to determine activity of the infection and offers a very helpful method of recognizing activity. It is going to be a very great help if we get some test, such as the sedimentation rate, which is fairly easy to carry out.

Dr. McGee also mentioned blood counts as a help in determining an acute infection. The average ambulatory cardiac child has a very variable leucocyte count even when the count is taken under carefully controlled conditions; it is of very little help in the ordinary child. In acute myocarditis we found some change in the number of mature and immature cells present in the count.

DR. E. B. SHAW (SAN FRANCISCO, CALIF.).—Has scarlet fever any etiologic significance in rheumatic carditis? Many cardiologists make quite a point of this in their case histories, but I have never been impressed with the evidence that scarlet fever initiates rheumatic fever or that it has more than chance relation to it.

Every good pediatrician must be able to express an authentic opinion regarding cardiac diagnosis in childhood; it is doubly important that the cardiologist who sees childhood cardiac problems have some breadth of pediatric training. If only we had better criteria for early diagnosis! There is usually no difficulty in working a diagnosis of valvulitis; any one can hear a murmur. But most of us have had the experience of seeing a child through a series of mild infections, not particularly suggesting rheumatism, and later discovering, without knowing its precise time of origin, signs of an acute valvulitis. In rheumatic fever, as in childhood tuberculosis, we are unable to detect clinical evidence of first infection and are able to make clinical diagnosis only with the appearance of exudative phenomena. As Dr. Schwarz suggests, what we need is a Pirquet type of test for rheumatic fever, something by which to pick the individual who is infected and who because of his altered reactivity may develop severely crippling lesions as a result of secondary infections.

A final point may appear fantastic. Englebach has suggested that hypothyroidism in the mother is a cause of congenital defects, such as failure of fusion of the septa in fetal life. In a small number of cases I have thought that the association of maternal thyroid disturbances and congenital heart disease in the infant were commoner than could be attributed to pure chance. In cases of patent septum, etc., diagnosed early in life, is there any rationale in giving thyroid extract to the infant?

DR. NICHOLS.—My suggestion to my cardiac staff is that we follow the doubtful cases for one or two years. I thoroughly agree with Dr. Gibson and Dr. McCulloch that, in certainly the large majority of cases, we can tell (even if we have to follow them six months or a year) which are the functional and which are the organic cases. We cannot offhand do that in a few minutes, but we can, certainly, in the great majority, by saying, "We will watch this child six months or a year." This brings up Dr. McGee's story of the potential group. I hope that some one here has the facilities and the staff to follow a large group of potential cardiac patients. We would all like to do that, but we have more actual cardiac patients on hand than we have time to accommodate. If some one would do that for a number of years, it might give us a lot of data that we would all like to have.

I would like to register a protest against the idea of putting all cardiac children to bed, unless they are proved to have progressive heart disease.

DR. GIBSON.—I do not know of any relationship between hypothyroidism and congenital heart disease. It is a well-known fact that congenital heart disease is unusually frequent in mongoloid infants. As far as I know, this is the only condition with which congenital cardiac anomalies seem to be especially associated.

Concerning the relationship of scarlet fever to rheumatic heart disease, I think that scarlet fever serves to activate rheumatic infection rather than being itself the cause of carditis.

CHAIRMAN McCULLOCH.—In a few instances, scarlet fever seems to be the first evidence of a rheumatic activity. It is also true that many rheumatic children who have scarlet fever show activity of infection to a considerable degree.

DR. MALINER.—I have noticed the presence of a peculiar murmur in suspected cases of adherent pericarditis. This murmur is of a very high pitch, located at the apex, usually occurring in late systole, and is superimposed upon the concomitant systolic murmur of the associated mitral valve lesion. Since this sound suggests the bleating of a lamb, I call it the "bleat" murmur. My explanation is that the murmur is due to a stretching of the pericardial adhesions during the systolic contraction of the ventricles.

DR. BRIGGS.—The question arises whether epistaxis means anything in rheumatic fever. We feel very strongly that epistaxis means a beginning of rheumatic fever and that it is a definite danger signal. Some observers, Dr. Coburn and others, feel that the early incipient stage of recurrent rheumatic fever is purpuric in character. Sometimes it shows in the nose, sometimes in ecchymotic areas and in a purpuric rash. This is the stage where rest is required as it is the earliest stage of rheumatic fever. It indicates a definite return of cardiac symptoms if rest is disregarded and the liberal use of salicylates is not followed.

(The remainder of the discussion followed the talks of Dr. McCulloch and Dr. Gibson repeated before the second Round Table discussion on Heart Disease, Tuesday afternoon.)

DR. WILLIAM M. CHAMPION (CLEVELAND, OHIO).—What form of digitalis do you use?

CHAIRMAN McCULLOCH.—We use the dry leaf of digitalis recommended by the American Heart Association and administer it in units based on the child's body weight. The tincture of digitalis is quite satisfactory. The tablets are easily taken, and the dry leaf does not deteriorate.

DR. PAUL G. ALBRECHT (CLEVELAND, OHIO).—I should like to inquire about exercise for cardiac patients. I have a patient who has been in bed for almost a year with rheumatism. During that time she has been very irritable and restless. What is the ultimate prognosis?

CHAIRMAN McCULLOCH.—My conception of that sort of child is that she is suffering from an active infection and when it will terminate is entirely problematical. Until it does terminate, one must continue that child's entire rest in bed with whatever other measures one might feel like using.

DR. ALBRECHT.—Have you used sodium cacodylate with any success at all?

CHAIRMAN McCULLOCH.—No.

DR. ORVILLE L. BALDWIN (COLUMBUS, OHIO).—How long do you keep patients in bed after acute rheumatic fever, after the fever has subsided and there is just a moderate heart involvement?

CHAIRMAN McCULLOCH.—If one can establish a rule—after a child has had an attack of exudative rheumatic fever, with joint pains and fever, we believe that a period of about three weeks is usually long enough to keep that child entirely

at rest in bed, if by that time he shows a normal pulse rate or one that is below a level of about 100 beats per minute, the standard arbitrarily established. The child should also be free of fever, or at least the temperature should be below 100° F. and varying not more than 1.5° F. over a period of observation; he should also be free of other symptoms, such as joint pains. If the child is, however, suffering from a proliferative type of rheumatic fever, I think that that period of rest should be lengthened to considerably more than three weeks. It takes longer for the child with proliferative rheumatic fever to attain a slow pulse rate and to lose his fever. Such children usually require from two to three months' rest after the cessation of their symptoms before they can be allowed out of bed. It also depends somewhat on the season of the year. When the child is getting over an attack of rheumatic fever in the spring, we usually keep him in bed a great deal longer than we would if he were getting over an attack during the summer or fall for the reason that rheumatic fever is more active and the child is more apt to have a relapse during the spring and early summer months.

In handling cardiac children, especially the ambulatory group, we have adopted a policy of keeping the child as nearly up to his limit of activity as possible; instead of putting him to bed in days of doubt, we assume that he should be allowed activity up to the point where he is not distressed. Under those conditions I believe the children are much happier, and their recovery is really as rapid, if not more so, than when they are confined to bed.

DR. ELI FRIEDMAN (BOSTON, MASS.)—What is the value of theocalcin in the acute stage of endocarditis?

The P-R interval, in my experience, is not prolonged usually in rheumatic heart disease in children as it is described in adults. In adults the P-R interval is very frequently prolonged. In children with acute rheumatic fever, the P-R interval was not prolonged.

Is there any difference between the myocarditis in diphtheria and the myocarditis in other toxic cases? In myocarditis due to diphtheria, very often there is left or right axis deviation and changes in the P-R interval. I think we do not see that often in myocarditis from other conditions.

The point you stressed about abdominal pain as a sign of myocarditis is particularly true in diphtheria because it is a very common symptom and is very often mistaken by the general practitioner for gallbladder disease.

How often do you get cerebral embolism in myocarditis, especially in diphtheria? I have seen just one case and I wondered whether you had occasion to see others. I presume the embolism was due to mural thrombosis following the fourth or fifth week of the illness.

CHAIRMAN MCCULLOCH.—A good many years ago we were trying to find some drug other than digitalis that might have some effect on the myocardium in cardiac children who were sick over a long period of time and who seemed to be progressing rapidly toward a fatal outcome in spite of all the efforts we were making. At that time we had used diuretin for its diuretic effect for the relief of edema, but we were seeking a drug that might have some effect on the myocardium for the relief of the edema.

We also believed that some of these children did not do well as a result of the nutritional changes existing in the myocardium and that nutritional disorders and deficiencies occurring early in infancy may determine in some degree the incidence of rheumatic fever. We thought these children might have a calcium deficiency in

the heart muscle along with other signs of calcium disturbance. Since theocalcin is a combination of theobromin and calcium salicylate, we thought it might be helpful for rheumatic children.

We have had a large number of children who have received theocalcin over a period of several weeks or months at a time to determine whether or not it has any beneficial effect in the child who does not have edema. I am of the opinion that these children are benefited by it as much or more than any other single drug that can be used. How it works, I do not know beyond this explanation.

It has been rather unusual to find a definite prolongation of the P-R interval in children with rheumatic fever and myocarditis.

The myocarditis in diphtheria is distinctly different from the myocarditis that occurs from any other form of an infection. I think those patients are in a class by themselves. It is truly a toxic myocarditis. In the milder cases the evidence of myocarditis is extremely slight, and by any ordinary microscopic examination, there is no evidence of a lesion. In the severer forms there is actual necrosis of cardiac muscle cells, particularly in the sinus nodes and the auricles. That type of myocarditis, however, is separate from the other types and is much more acute.

You mentioned the importance of abdominal pain and vomiting in children with acute myocarditis, and I am very glad to reemphasize it. In the treatment of this condition, we have been impressed by the value of intravenous glucose in controlling the vomiting and abdominal pain. The glucose can be given intravenously in very large amounts. We usually give enough insulin to combine about half the glucose. It is interesting to note that many of these patients with pain ask for the glucose injections for relief. It is a very satisfactory form of treatment, and, again, we are not certain as to just how it works.

All cardiac children of this type have a low blood sugar content, and it is probable that their glycogen storage throughout the blood is somewhat low and the glucose they receive does no more than restore that substance.

We have never observed cerebral embolism in a child with diphtheritic myocarditis. I do not know what would cause it. I rather agree with you that it might be due to different factors.

DR. ELI FRIEDMAN.—There are fifteen cases of hemiplegia following myocarditis reported in the literature. What do you think is the cause of the abdominal pain? Is it all due to congestion of the liver, or is it nerve pain through vagus stimulation?

CHAIRMAN McCULLOCH.—It may be due to the acutely engorged liver with distention of the capsule, but it can be observed in children who do not have congestive failure, whose livers are not very much enlarged.

DR. THOMAS A. FOSTER (PORTLAND, ME.).—You spoke of chorea in connection with rheumatic fever. Has it been your experience that chorea does the same thing to the myocardium and endocardium that rheumatic fever does? The more I see the infection which I think is rheumatic fever of childhood the less I think it has to do with chorea or that chorea has to do with rheumatic fever.

CHAIRMAN McCULLOCH.—My feeling is that chorea is a manifestation of rheumatic fever in the brain; that chorea is a form of encephalitis due to rheumatic fever in the same way that a lesion in the lung or a lesion in the myocardium or a lesion in the joint may occur. Chorea itself does not cause the myocardial lesion, but they are a joint offspring of a common parent which is the rheumatic state.

DR. WILLIAM M. CHAMPION (CLEVELAND, OHIO).—How about an encephalitis in those cases you are now calling real choreas? Did you ever see that suggestive movement of chorea? Why not encephalitis?

CHAIRMAN McCULLOCH.—There are children who may have had encephalitis at some time in their lives when the disease was not recognized and as a result, the child has clumsy athetoid movements all the time. Some of those children for various reasons such as physical strain, fatigue, or infections may become mildly choreic, and they, too, may not be rheumatic in nature. They are not very common, however.

When I say that chorea is a form of encephalitis due to rheumatic fever, it is essentially different from the ordinary forms of encephalitis because chorea rarely ever leaves any residual effect in the brain provided that one did not exist before the attack. Effects such as paralysis or mental disturbances do not last longer than a few weeks in these children. At autopsy when the brain is examined, it is very rare, except in very acute cases, to find any morphologic change in the brain itself such as you find in a true encephalitis.

DR. FOSTER.—Is the percentage of heart involvement as great with chorea as with any type of rheumatic infection?

CHAIRMAN McCULLOCH.—I think it is. If you examine those patients over a long enough period of time, for example, if you follow them into adult life, nearly every one of them shows signs of rheumatic fever in some form later on.

Also in working out the family relationships of rheumatic fever, it has been quite interesting to note that a good many parents, especially mothers who have had chorea in childhood, have a rheumatic child with heart disease. That is a quite common occurrence.

DR. CHAMPION.—The University Hospitals of Cleveland consist of Lakeside Hospital, Babies and Childrens Hospital, Maternity Hospital, and Rainbow Hospital. The last named is out in the country about ten miles from the main group. It is a convalescent hospital for both pediatric and orthopedic children. Dr. Norman C. Wetzel is the visiting pediatrist in charge of the cardiac cases. He has been using the sedimentation rate to determine when to let a child up. You have not mentioned this test, and I am wondering what you think about it for this purpose.

CHAIRMAN McCULLOCH.—I, personally, have not been using this test at all, although I am familiar with it and have been noting the results of other workers who have been reporting, apparently, that it is very favorable and a very satisfactory test to use. It may be a little difficult but, apparently, it is very satisfactory to indicate a loss of rheumatic activity. And any such test, of course, will be of extreme value because it is very difficult under conditions that you have at Rainbow Hospital with convalescent children to say when the rheumatic infection is no longer active; any such test would be very welcome.

DR. CHAMPION.—From my observation the sedimentation rate seems to be an excellent way of determining when the cardiac infection has become quiescent. Some children are kept in bed longer and some a shorter time than they would have been before the use of this test. The net result, however, seems to be very much better.

DR. E. S. WEGNER (LINCOLN, NEB.).—What is the value of blood pressure readings in determining activity of the rheumatic infection? Do you give any attention to blood pressure readings in determining when to allow these patients more exercise?

CHAIRMAN McCULLOCH.—The blood pressure is not changed except in cases with aortic insufficiency. The ordinary patient with rheumatic fever has no change in his systolic or diastolic blood pressure. In cases with aortic insufficiency, the blood pressure may be of some value in determining when the patient is ready for exercise. We believe that a pulse pressure of 50 millimeters of mercury should be the maximum before activity is allowed. A child with more than 50 millimeters of pulse pressure should be kept in bed.

DR. E. R. McCLUSKEY (PITTSBURGH, PA.).—You spoke of the rheumatic state. Students have pigeonholed all of these rheumatic conditions as separate entities and give very little thought to the rheumatic state.

I should like to ask Dr. Gibson about so-called idiopathic hypertrophy. Could congenital atelectasis of the lung be a factor in hypertrophy, or may overfunction of the infantile adrenal gland be important?

CHAIRMAN McCULLOCH.—The question of the rheumatic state was taken up last year. I feel very definitely, as you do, that we must learn to recognize heart disease only as a part of a rheumatic state. "Rheumatism" is a general term used to include many lesions throughout the body, and I think the term should be used in the same way that one recognizes tuberculosis in children. The lesion in the heart from rheumatism is really something comparable to the lesion in the lung of tuberculosis. It is only one phase of this disease state that might be present in an individual at a given time. This idea will gradually seep through to medical students in due time.

DR. McCLUSKY.—I found it very hard to get it across.

DR. GIBSON.—There is one thing I would like to ask you, Dr. McCulloch. You said that in cases of serofibrinous pericarditis you might have complete recovery. How are you going to be sure of that?

CHAIRMAN McCULLOCH.—We have a good many children who have had attacks of acute serofibrinous pericarditis who seem to be perfectly well after several years or in whom nothing was found in the pericardium when they came to autopsy later from heart disease.

DR. GIBSON.—We have recently reviewed seventy-three autopsies at the Children's Memorial Hospital. In these autopsies we made particular note as to the presence or absence of pericarditis. Since we had only ten cases without evidences of pericarditis at autopsy, I feel that the very great majority of children, if one cannot prove it during life, do have pericarditis as shown at autopsy. Out of the ten children who did not have pericarditis, four of them died a noncardiac death. We thought they might have developed a pericarditis if they had lived long enough.

We have not had the experience of having been able to make a definite diagnosis of pericarditis and then failing to find it at autopsy. I am very much interested in your findings.

CHAIRMAN McCULLOCH.—Did those six patients who died a cardiac death and who showed no pericarditis have anything in their history or in their previous examination to indicate that they had an attack of pericarditis?

DR. GIBSON.—We did not accept anything for a diagnosis of pericarditis unless we could hear a friction rub. We felt that was the only thing we could be sure about. I am quite sure we did not hear a friction rub in any one of those six cases.

CHAIRMAN McCULLOCH.—We have had several children in whom we have heard a friction rub and in whom at autopsy no evidence of pericarditis could be found. I am interested in your statement about the large number of patients who were found to have pericarditis when examined at autopsy. That has been our experience, too, Most of those who die a cardiac death have pericarditis.

DR. GIBSON.—In a little less than half of the cases we heard pericardial friction. Of course, they did not run their entire course in the hospital; they may have had the pericardial friction before they came in, but there was a wide discrepancy between the number of friction rubs heard and those that actually had pericarditis.

The meeting adjourned at 5:15 o'clock.

Academy News

The following Committee on Nursing Education in Pediatrics has been appointed:

Dr. William P. Lucas, Chairman, San Francisco
Dr. William A. Mulherin, Augusta, Georgia
Dr. Stanley Gibson, Chicago
Dr. Charles A. Weymuller, Brooklyn, New York.

The name of the Committee on Relation of the Academy to Philanthropic Agencies, Welfare Workers, etc., has been changed to the "Committee on Child Health Relations."

The annual fall meeting of Region IV of the Academy will be held in Oakland, Calif., on October 26 and 27. The program will be as follows:

Friday, October 26: Symposium on Contagious Diseases
Symposium on Bronchosinus Disease
Pneumonia
Allergy

Saturday, October 27: Case Reports

In the afternoon, the Fellows will attend the annual Stanford-Southern California football game at Stanford University.

The following program has been arranged for the Regional meeting of the Academy to be held in San Antonio in conjunction with the Southern Medical Association, Wednesday, November 14, 1934.

9 A.M. Round Table Discussions. Members of the Academy as well as members of the Southern Medical Association are invited to attend these discussions. Those who contemplate being present are asked to notify Dr. E. C. Mitchell, 1073 Madison Avenue, Memphis, Tenn., at their earliest convenience, making a first and second choice so that tables may be assigned.

2 P.M. Business meeting of the Academy for members. In addition, all state and city health commissioners are invited. Immediately following the business meeting of the Academy, there will be a meeting of the Regional Board and state chairmen.

7 P.M. Joint banquet with the Pediatric Section of the Southern Medical Association. Dr. Hugh McCulloch will speak on "Heart Affections in Children." Dr. Clifford Grulee, secretary of the American Academy of Pediatrics, will discuss the aims and purpose of the Academy. He will also take up the subject of "The Value of Certification by the American Board of Pediatrics." This banquet will be presided over by Dr. Oliver Hill, Chairman of the Section on Pediatrics of the Southern Medical Association.

News and Notes

The Central New York Pediatric Club composed of physicians from Rochester, Albany, Schenectady, Syracuse, Auburn, Watertown, and Troy, met in Auburn on September 20. The scientific session was held at the Auburn Hospital. Dinner was had at Springside Inn in the evening, at which time Dr. Don Cadzow, prominent archeologist addressed the group. This group usually meets four times a year in various cities of central New York.

The pediatricians of Montreal, Quebec, central and western New York will attend a meeting to be held by the pediatricians of Montreal in that city some time in November. For the past five or six years, the pediatricians of this group have been meeting in one of the larger cities in central and western New York, or in Montreal or Toronto, for a clinical conference. Last year the meeting was held at Rochester and this year it will be held in Montreal.

The following officers of the Southwestern Pediatric Society were elected on May 9, 1934:

Dr. Victor E. Stork, Los Angeles, President

Dr. Philip E. Rothman, Los Angeles, Vice-President

Dr. Howard R. Cooder, Los Angeles, Secretary-Treasurer.

Comments

WHILE the primary purpose of the hospital is the care of the sick patient, it has another function which is so intimately involved with this basic purpose that it is impossible of separation. This is the function of education—education of the patient, parent, nurse, medical student, interne, and attending staff. The hospital is the chief organized unit for the study of disease and therapeutic advance. The level of the medical profession in a given community can be fairly well estimated by the character and work of its hospitals. In the same way the position and degree of development of a special field of medicine can well be evaluated by a study of the hospitals in this restricted field.

The report of the Academy Committee on Hospitals and Dispensaries, which has recently been appearing in the Journal (Vol. 4, pp. 418, 561, 838, and Vol. 5, pp. 274, 422) is important and is indicative of the types of study which should be carried out by the Academy of Pediatrics. As a whole it leads to the conclusion that the hospitals for children in the United States and Canada are excellent. The Hospital Committee has wisely confined its study to the thirty-five hospitals designed exclusively for and limited to children. In addition there are many excellent pediatric wards or departments connected with or a part of large general hospitals. With some notable exceptions the progress in pediatric hospital service has, however, largely taken place in the hospitals limited to the care of children. The Academy report gives many illuminating details as regards the character of service, the staff, x-ray and laboratory facilities, the cost of hospital service, dispensary facilities, the character of the nursing organization and the like, which are important and which should stimulate some of the hospitals to improve the details of equipment and standards.

Reports such as this are of necessity limited to organization details and physical equipment. Such intangible items as the "spirit" and "morale" of the hospital organization, the interest and work in research, the teaching interest and attitude of the visiting staff toward the house staff cannot be charted into figures and graphs, and yet in the final analysis it is these matters which make one hospital superior to another. Some of this intangible element is found in the description of individual hospitals and clinics which has appeared in recent months in the series of Pediatric Clinics. We have a very strong feeling that as a rule the hospitals with superior equipment and broad organization have these things largely as a result of a finer spirit and morale. The report is an excellent study and to those who have already read it as it has appeared by sections, we suggest a rereading as a whole.

THE Council on Medical Education of the American Medical Association in its 1934 report (J. A. M. A., Aug. 25, p. 565, 1934) lists eighty-six hospitals as approved for the training of house officers in pediatrics. The Academy report totals 251 available house services of a year each (internes, assistant residents, and residents) in the thirty-five hospitals included in its report. The A. M. A. report lists fifty-four additional hospital services, with 115 twelve-month appointments to the resident staff. As two years of specialized hospital training are today regarded as necessary for those intending to specialize, in addition to the general interne

year, and making allowance for men taking three years of pediatric house service, it is apparent that from 150 to 175 well-trained younger men are at the present time entering the practice of pediatrics as a specialty. Most certainly inadequate training can no longer be excused on the ground of lack of opportunity in American hospitals and clinics. That 150 men can be absorbed yearly is a question in itself and emphasizes the necessity of the recent movement in American medicine to develop educational requisites for specialization.

Approximately 3 per cent of our 5,000 yearly graduates in medicine in the United States are being adequately trained in pediatrics, and it is obvious to anyone familiar with the situation that at least another 1 per cent is entering the field with insufficient training. Of the 154,495 physicians listed in the 1934 Directory of the A. M. A., 1,734 (1.1 per cent) report as practicing pediatrics exclusively, and 2,155 (1.4 per cent) as having a particular interest in the field. Thus 2.5 per cent of all physicians are today engaged in the field of pediatrics.

THE most amazing item in the Academy report is to be found in the first paragraph on page 562, vol. 4, although we question its importance in the field of pediatrics. We here learn that the Mississippi River has changed its course. Our first feeling was that this might be a result of the "New Deal" we had overlooked, or perhaps had been caused by the recent midwestern drought. Recalling that we had recently seen "Ole Man River" meandering along its usual muddy channel from Minneapolis to New Orleans, we finally reached the conclusion it is a fortunate thing (for the committee at least) that geography is not included among the examination subjects of the Board of Pediatrics.